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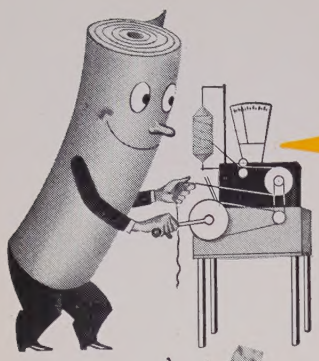

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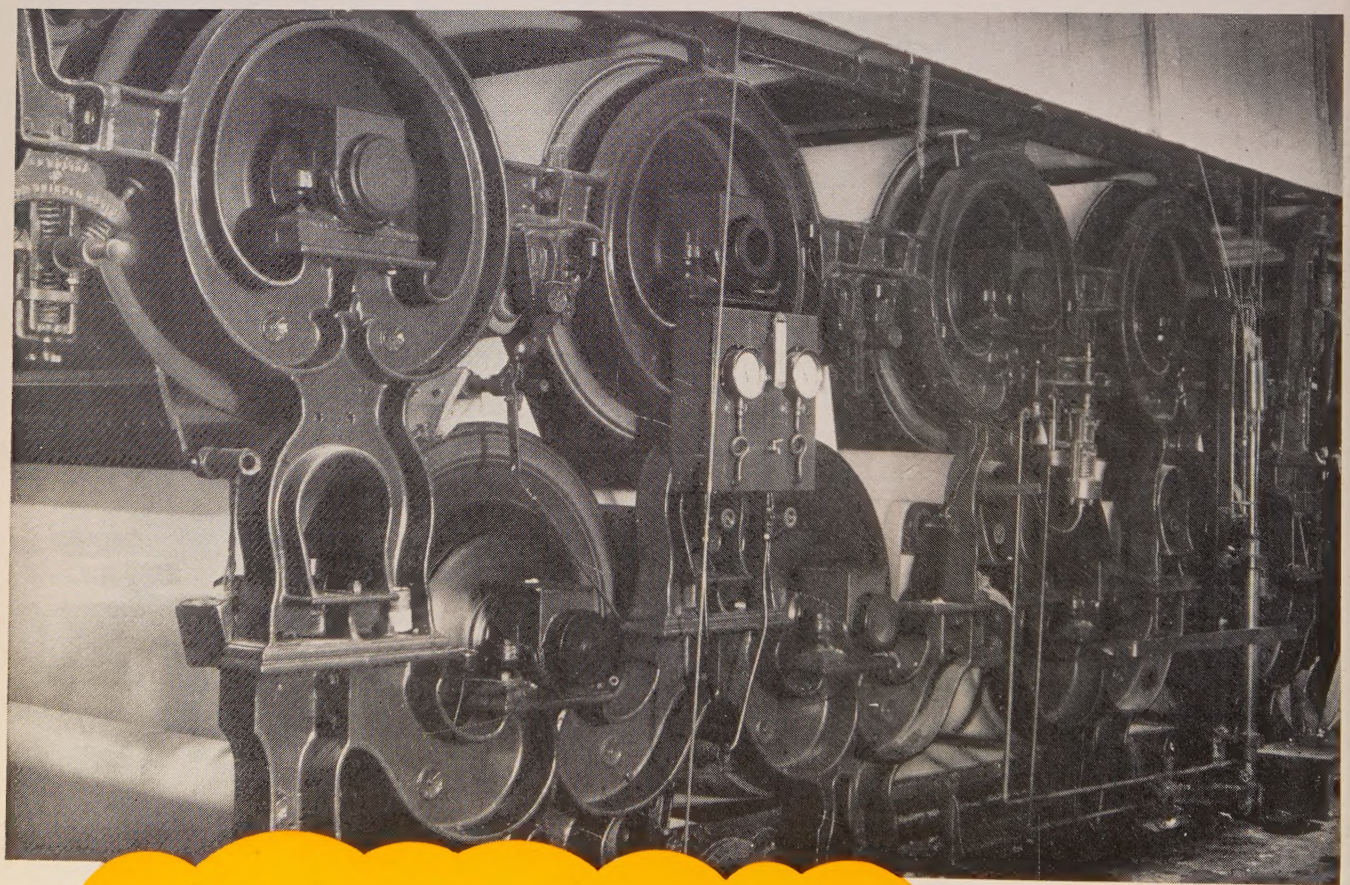

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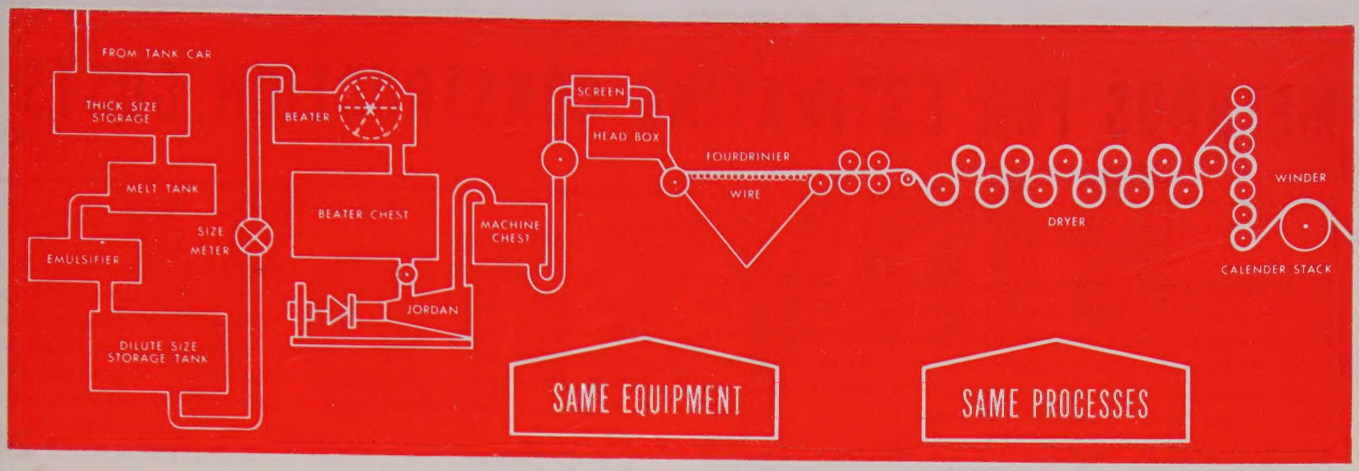

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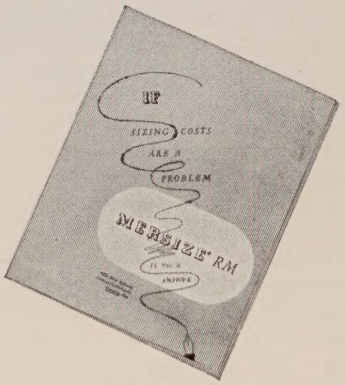

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METHODS FOR ESTIMATING CONSTRUCTION COSTS*

Publication of the following two articles has been arranged by the TAPPI Committee investigating "Methods for Quickly Estimating Construction Costs." The first article by R. A. Dickson was published in "Chemical Engineering," January, 1950, and also appears in slightly different form in the book "Industrial Piping" by C. T. Littleton and R. A. Dickson published by the McGraw-Hill Book Co. ($8.00 per copy). Piping represents a high proportion of equipment cost in most types of process plant. Further than that, its estimation is usually quite laborious. The *N* system, as developed by Mr. Dickson, is based on the simple fact that the cost of a string of any size pipe bears a predictable relation to the cost of the same string in another size. Hence, only the cost of the "reference" string in each kind of pipe need be kept up to date. In Mr. Mrachek's paper the author describes another method of estimating piping costs which he claims to be accurate within 5% on actual construction.

Pipe Cost Estimation

R. A. DICKSON

PIPING always represents a sizable part of the total installed cost of any process plant. It may run to 20%, or even more, of the entire cost of the plant including land and buildings and may total from around 10% to as high as two thirds of the cost of the equipment. But piping is usually complicated and often consists in a myriad of small, generally rather inexpensive parts. Its estimation can therefore be a headache to the estimator.

It makes his problem no easier that he is often called upon to prepare a reasonable estimate long before final plans are in existence, and before the project engineers have any idea how much piping will actually be needed. In this case he must not only be an estimator, but he must be able quickly to convert the preliminary flow sheet into a fair approximation of an actual design so that he may know what his estimate will involve. For this purpose the ability to make quick and rather accurate free-hand isometric sketches is of inestimable value.

However, the estimation of the piping need not be very arduous if the estimator will make use of the *N* system developed by the author during the last several years. This system, first disclosed in *Chemical Engineering* two years ago (R. A. Dickson, *Chem. Eng.*, November 1947, pp. 121–123), has now been carried much farther and includes most kinds of pipe with which the chemical engineer is likely to be concerned. Through its use it is ordinarily necessary to have up-to-date cost data on only one size of each kind and class of pipe on which estimates may be necessary. If the estimator is willing to sacrifice some degree of accuracy, even that amount of keeping up with costs will not be needed, for the present article includes not only the "system" but also the data, which are accurate to July, 1949.

R. A. DICKSON, Engineer, Caldwell, N. J.

* This material was submitted by the Methods for Quickly Estimating Costs of Engineering Projects Subcommittee, H. G. Ingraham, Chas. T. Main, Inc., Chairman. An opinion as to the value of such material will be of great assistance to the committee in the development of its plans and the possible publication of information of a similar type in the future.

The *N* system is based on the simple idea of recording, once and for all, the relative costs of various sizes of the same kind and class of pipe made up into a "string" consisting of pipe, fittings, and valves. If one string of pipe taken as standard costs X dollars, and the same string made of another size of the same kind of pipe costs Y dollars, both installed, then $X/Y = N$. The *N* factor for each size can be calculated by actually figuring the cost of each string and comparing it with the cost of an arbitrarily chosen standard or "reference" string. The *N* factors can then be recorded as a tabulation, or they can be plotted against nominal pipe size as a more or less smooth curve, as in this article. It is unimportant whether the resulting curve is entirely smooth or not. The important thing if that, although the absolute costs may vary widely over a period of time, tests have shown that the relative costs vary inappreciably. This means that with a table of *N* factors for any kind and class of pipe, it is necessary only to keep up with the cost variations for the reference size.

The main thing this article contributes, therefore, is a group of 66 *N* factor tabulations, some grouped, plotted in the 40 charts listed in Table II. Some are for bare pipe, some for 400°F., 800°F., or 0 to −25°F. insulated pipe. Some are for a standard weight of pipe, such as Sch. 40, some for a heavier grade such as Sch. 80. In the case of the stainless alloys, some are also for the zephyr-weight grade. The list includes 21 different construction materials, but if different grades or weights of the same material are counted, this brings the total to 31. For 29 kinds and grades of pipe hot insulation costs are given, with cold insulation costs for 11.

In addition to the *N* factor plots, the article gives material and labor costs for the reference size in each *N* factor plot, based on July, 1949, costs in the New York area. The data are presented as material, labor, and total for: (1) 1 ft. of pipe; (2) one fitting, figured as a tee; and (3) one valve of the type specified in the caption for each chart. Incidentally, the abbreviations in these captions may be interpreted with the aid of Table III. In the original calculation each string was calculated as 1000 ft. of pipe containing one fitting and one valve, since otherwise it would be impossible to allocate cost of welding, pipe fitting, bolting up flanges, and other factors to a single foot of pipe. The costs of materials and labor chargeable to the pipe were then divided by 1000 to give the cost per foot of pipe.†

As an example of the form used in calculating the cost of each string for an *N* factor table or curve, consider the data in Table I pertaining to the reference size (2 in.) of the curve for low-temperature insulated pipe in Fig. 35. This particular calculation was selected for inclusion here because it shows practically every factor that may have to be included when doing such a job. It also offers a handy form for making cost calculations of the reference string for any kind and class of pipe when the estimator is using current cost data together with the *N* factor curves.

Table I is based on 2-in. type 304 zephyr-weight stainless steel, insulated with special brine thickness cork. The specifications are given in Fig. 35.

It will be noted that the totals in the right-hand column of the table give the same data as are listed for cold-insulated

† Note that the *N* factor tables cover only the cost of the pipe string itself and do not include cost of burying or supporting the line, costs for which are too variable to include in cost tables. Calculation is not difficult. Many installations are supported on existing structures or laid on the ground.

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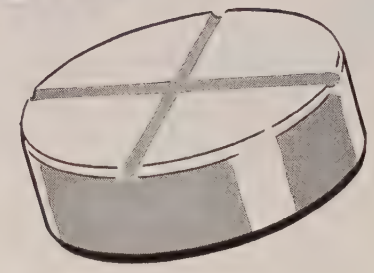

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Table I. Example of Pipe String Calculation (Fig. 35)

2-in. pipe, 1000 ft. at $2.35	$2350.00		
2 × 6-in. flanges, 10 at $6.65	66.50		
Bolts and gaskets	23.34		
Weld rod, 11.5 lb. at $0.75	8.63		
Insulation, 1000 ft. at $3.50	3500.00	Matl.	$ 5.95
Miscellaneous	1.53	Labor	1.41
	$5950.00		$ 7.36
Handle and haul, 35 pc. at $0.12	$ 4.20		
Sc.-ups (flanges), 6 at $2.00	12.00		
Welds, 50 at $1.13	56.50		
Insulators, 1000 ft. at $1.33	1330.00		
Miscellaneous	2.30		
	$1405.00		
2-in. fitting	$3.30		
Weld rod	0.75		
Insulation	7.70		
Miscellaneous	0.25	Matl.	$12.00
		Labor	6.50
	$12.00		$18.50
Handle and haul	$0.12		
Welds, 3 at $1.13	3.39		
Insulators	2.82		
Miscellaneous	0.17		
	$6.50		
2-in. valve	$63.00		
Flanges, 2 at $6.65	13.30		
Bolts and gaskets	0.66		
Weld rod	0.75		
Insulation	10.35		
Miscellaneous	4.29	Matl.	$92.35
		Labor	12.15
	$92.35		$104.50
Handle and haul	$0.36		
Sc.-ups, 2 at $2.00	4.00		
Welds, 2 at $1.13	2.26		
Insulators	4.15		
Miscellaneous	1.38		
	$12.15		

pipe under Fig. 35. In Fig. 35 and a few others where there are too many data for the available space, it has been necessary to break down the totals for costs of 1 ft. of pipe, one fitting, and one valve into their material and labor components in a separate footnote. In most cases, material (M), labor (L), and total (T) have been listed directly in the caption for 1 ft. of pipe (P), one fitting (F), and one valve (V).

Before going on to the use of the *N* factor charts, it will be worth while considering a few points concerning their method of derivation. In welded lines the cost of a flanged joint is included for each 200 ft. In any string having a screwed valve, provision is made for a union adjacent to the valve. In screw-joined strings the cost includes necessary couplings, and in flange-jointed strings, all necessary flanges, as well as bolts and gaskets. Allowance is made for cost of handling and hauling all parts, for pipe-fitting, welding, weld rod, caulking materials in bell and spigot joints, and screw-ups of both screwed and bolted joints. Insulated strings include the cost for both material and labor in insulating each part with 85% magnesia for 400°, 85% magnesia and Superex for 800°, and special brine thickness cork for 0 to −25° insulation.

HOW *N* SYSTEM IS USED

As already mentioned, there are two ways in which the *N* system can be used: either with current data for the reference size of each kind needed, or by use of the reference size data given here. If the latter method is used, the accuracy will not be as high as by the first method and will depend on the accuracy with which the user can "factor" the July, 1949 costs used here to the actual date of use. Unfortunately there are no very satisfactory methods regularly available for converting piping costs of one date to those of another.

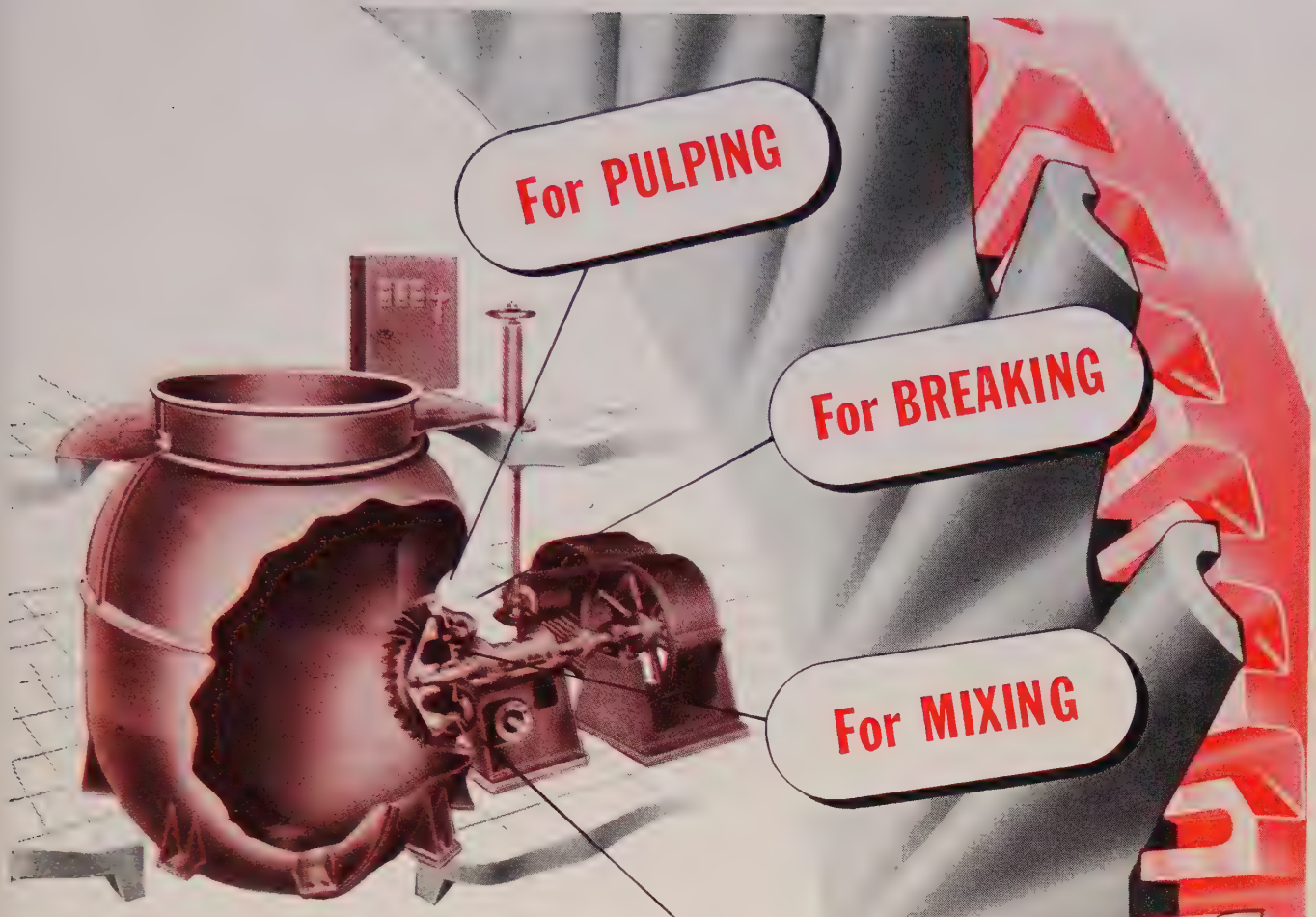
Table II. Piping Materials Covered in Figs. 1 to 40

Pipe	*Fig. No.*
Aluminum, std. wt., bare	1
Aluminum, std. wt., insulated 400°F. and 0 to −25°F.	2
Asbestos-cement, classes 100 and 150	3
Brass, i.p.s., std. wt., bare	4
Brass, i.p.s., std. wt., insulated 400°F.	5
Brass, i.p.s., extra heavy, bare	6
Brass, i.p.s., extra heavy, insulated 800°F.	7
Brass, i.p.s., std. wt., silbrazed, bare	8
Brass, i.p.s., extra heavy, silbrazed, bare	9
Brass, i.p.s., std. wt., silbrazed, insulated 400°F.	10
Brass, i.p.s., std. wt., silbrazed, insulated 0 to −25°F.	11
Cast iron, bell and spigot, class C, 16-ft. lengths	12
Duriron	13
Durichlor	14
Glass, Pyrex	15
Inconel (use type 316 charts Figs. 28–31 incl.)	
Lead, chemical, $^3/_{16}$-in. wall	16
Lead, chemical, $^1/_4$-in. wall	17
Monel (use type 304 charts, Figs. 32, 33)	
Nickel (use type 316 charts, Figs. 28–31, incl.)	
Porcelain	18
Steel, pre-insulated 300°F., std. wt.	19
Steel, pre-insulated 500°F., extra heavy	20
Steel, butt-welded, std. wt., black, bare, and insulated 400°F.	21
Steel, butt-welded, std. wt., galvanized, bare and insulated 400°F.	21
Steel, seamless, std. wt., black, bare	23
Steel, seamless, std. wt., black, insulated 400°F. and 0 to −25°F.	24
Steel, seamless, extra heavy, black, bare, and insulated 800°F $^1/_8$ to 3 in.	25
Steel, seamless, extra heavy, black, bare, 4 to 24 in.	26
Steel, seamless, extra heavy, black, insulated 800°F., 4 to 24 in.	27
Steel, stainless, types 316 and 347, std. wt., screwed joints, bare	28
Steel, stainless, types 316 and 347, std. wt., screwed joints, insulated 400°F.	29
Steel, stainless, types 316 and 347, std. wt., welded, bare and insulated 400°F.	30
Steel, stainless, types 316 and 347, std. wt., welded, insulated 0 to −25°F.	31
Steel, stainless, type 304, std. wt., bare and insulated 400°F. and 0 to −25°F.	32
Steel, stainless, type 304, extra heavy, bare and insulated 800°F.	33
Steel, stainless, type 316, zephyr wt., bare and insulated 400° F. and 0 to −25°F.	34
Steel, stainless, type 304, zephyr wt., bare and insulated 400° F. and 0 to −25°F.	35
Steel, stainless, Type 347, zephyr wt., bare and insulated 400° F. and 0 to −25°F.	36
Steel, lead-lined, $^3/_{16}$ in. thick	37
Steel, rubber-lined, $^3/_{16}$ in. thick	38
Steel, Saran-lined, std. wt., screwed	39
Steel, Saran-lined, std. wt., flanged	40

Table III. Abbreviations Used in Captions

Al.	aluminum	Mag.	magnesia
B & S.	bell and spigot	O S & Y.	outside screw & yoke
brs.	brass	P.	pipe
brz.	bronze	Pb.	lead
CI.	cast iron	rl.	rubber lined
cwp.	cold water pressure	S.B.T.	special brine thickness
deg. F.	degrees Fahrenheit	scr.	screwed
F.	fitting	Ser.	series
fgd.	forged	slb.	silbrazed
fl.	flanged	S.S.	stainless steel
Fl.	flanges	Std. wt.	standard weight
g.	gate	stl.	steel
insul.	insulated or insulation	T.	total cost
i.p.s.	iron pipe size	th.	thick or thickness
L.	labor cost	V.	valve
ll.	lead lined	wld.	welded or welding
M.	material cost	XH.	extra heavy

Note: Superior numbers in captions refer to footnotes at end of article detailing costs where insufficient space for all figures exists in captions.



MORDEN *SLUSH-MAKER*

The controllable bar-to-bar action of the "Slush-Maker's" rotor and bed plate (shown enlarged at right) is the answer to rapid, efficient and complete pulping and deflaking of all pulps and paper stocks—even high wet strength.

The circulating action of the rotor blades quickly blends and mixes various pulps along with color, size and other additions to the furnish.

The bar-to-bar action may be set up to give a preliminary beating treatment to the stock or to brush the color and size into the fibers.

The "Slush-Maker" completely prepares the stock for final fiber treatment in "Stock-Makers" or other beating and refining equipment.

We are prepared to run a "Slush-Maker" demonstration for you—let us know your pulping requirements.

SLUSH-MAKER

MORDEN

Machines Company

STOCK-MAKER

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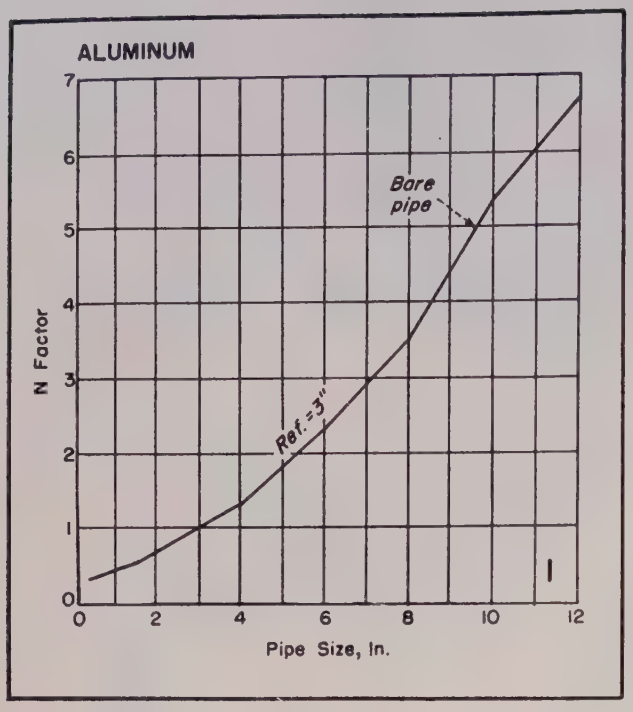

Fig. 1. Aluminum: Pipe, alloy 61S-T6, std. wt., 1/2 to 12 in., welded, bare. Fittings, Al, welding. Valves, Al scr. gate to 1 in., Al flanged gate, 1 1/2 to 12 in. 125 lb.

	3 in.		
	M	L	T
P	$ 1.96	0.11	2.07
F	15.00	7.00	22.00
V	135.00	12.00	147.00

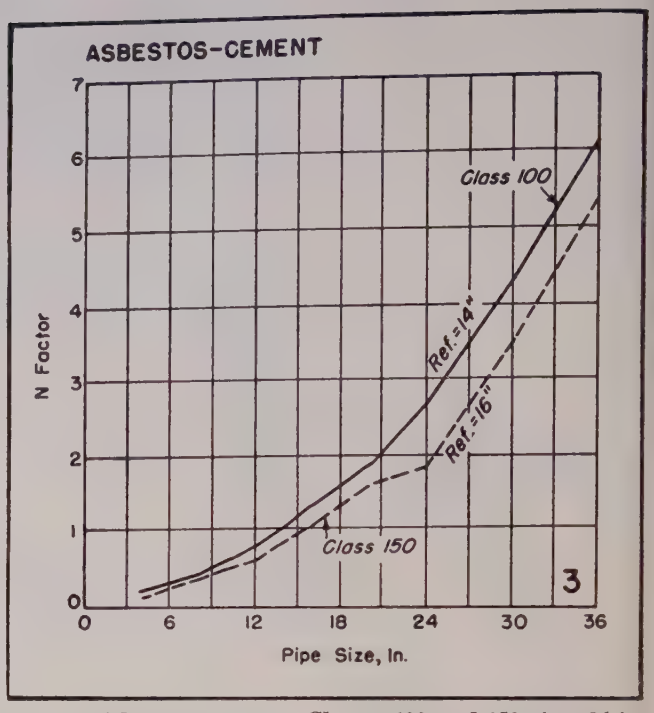

Fig. 3. Asbestos-cement: Classes 100 and 150, 4 to 36 in. Fittings, CI, all bells, class D. Valves, C.I.B.M. flanged gate OS & Y 125 lb. for class 100, 250 lb. for class 150

	14 in., class 100			16 in., class 150		
	M	L	T	M	L	T
P	$ 4.10	0.20	4.30	$ 5.80	0.35	6.15
F	70.00	15.00	85.00	90.00	20.00	110.00
V	400.00	35.00	435.00	900.00	40.00	940.00

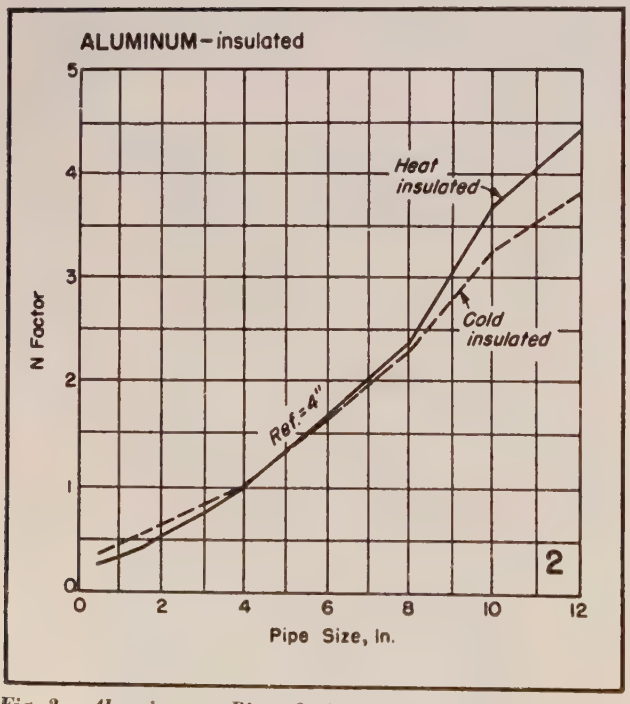

Fig. 2. Aluminum: Pipe, fittings and valves same as Fig. 1; 1/2 to 12 in. Insulated 85% mag. 400°, S.B.T. cork for 0 to −25°F.

	4 in., 400°			4 in., 0 to −25°		
	M	L	T	M	L	T
P	$ 3.59	0.40	3.99	$ 7.46	1.96	9.42
F	21.41	10.15	31.56	31.50	14.00	45.50
V	175.41	15.15	190.56	197.30	23.45	220.75

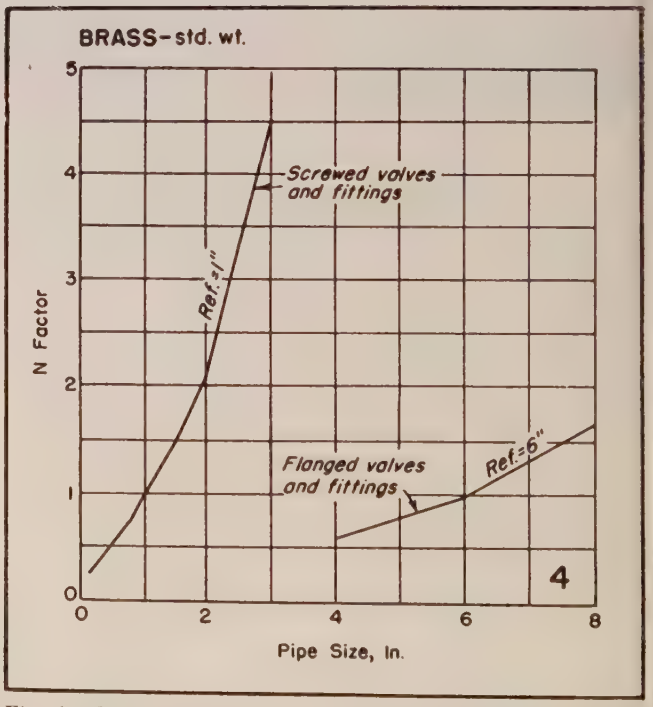

Fig. 4. Brass, red: Pipe, i.p.s., std. wt., 1/8 to 8 in., bare. F to 3 brz. scr. 125 lb.; 4 to 8 in. brz. fl. 150 lb. V brz. scr. g. 200 lb. cwp. and brz. g. fl. 150 lb.

	1 in.			6 in.		
	M	L	T	M	L	T
P	$0.90	0.08	0.98	$ 11.31	0.60	11.91
F	1.02	1.18	2.20	160.00	30.00	190.00
V	8.00	1.60	9.60	210.00	30.00	240.00

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Continuous bleaching with Hydrogen Peroxide at 25%-40% density is now a reality for groundwood, semi-chemical, and chemical pulps in crumb form. Semi-continuous steeping of these pulps without retention towers is also a commercial operation. Screw presses will perform the function of de-watering to high densities.

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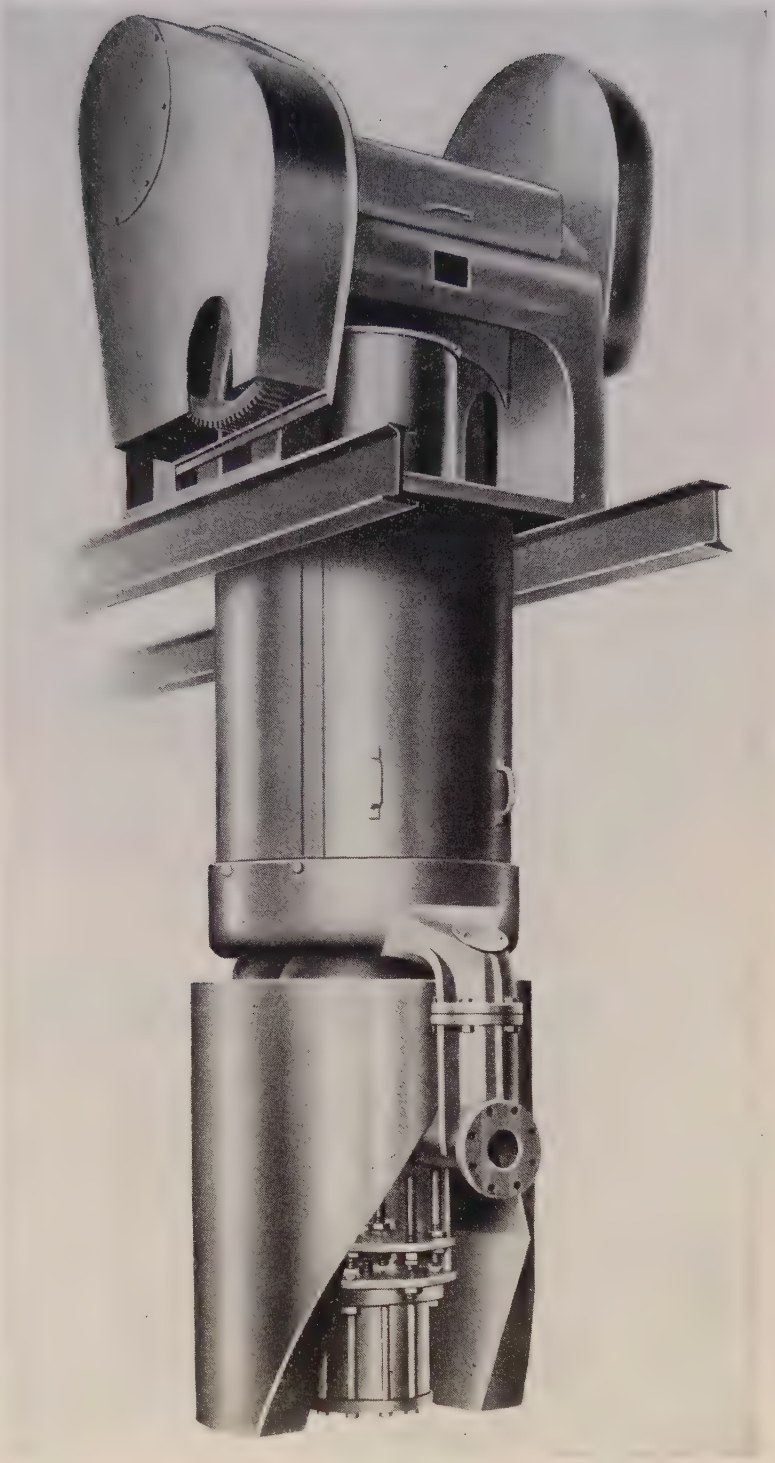
To obtain the same brightness level, chemical cost reductions due to high density operation (25%-40%) have been up to 20% for groundwood, up to 25% for neutral sulfite semi-chemical, and up to 45% for sulfite, compared with moderate density (10%-14%) systems.

For further information on the most efficient peroxide methods, write to Becco.



A Jackson & Church Zenith Medium Press typical for use in de-watering high density pulp crumbs.

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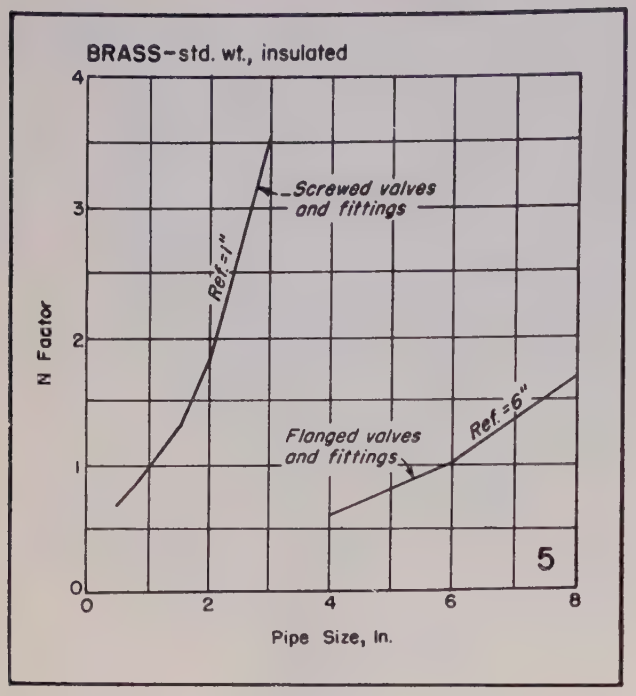

Fig. 5. Brass, red: Pipe, i.p.s., std. wt., 1/2 to 8 in. Fittings and valves, same as Fig. 4. Insulated 400°F., using 85% mag. 1 1/2 in. th. to 3 in., 2 1/4 in. th. 4 to 8 in.

	1 in.			6 in.		
	M	L	T	M	L	T
P	$1.22	0.29	1.51	$ 13.34	0.85	14.19
F	1.20	1.20	2.40	161.00	30.00	191.00
V	8.20	1.60	9.80	211.00	30.00	241.00

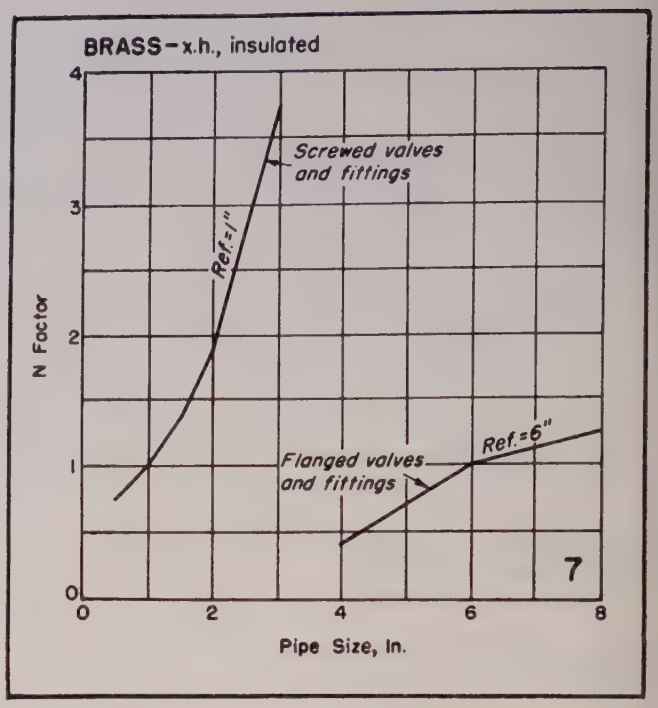

Fig. 7. Brass, red: Pipe, i.p.s., XH, 1/2 to 8 in. Insulated, 800°. Fittings same as Fig. 6, valves as in Fig. 6 except 300 lb. Insulation sponge felt and Superex, 800°F.

	1 in.			6 in.		
	M	L	T	M	L	T
P	$2.34	0.37	2.71	$ 25.44	0.88	26.32
F	1.77	1.31	3.08	272.73	20.68	293.41
V	8.27	2.06	10.33	332.73	15.68	348.41

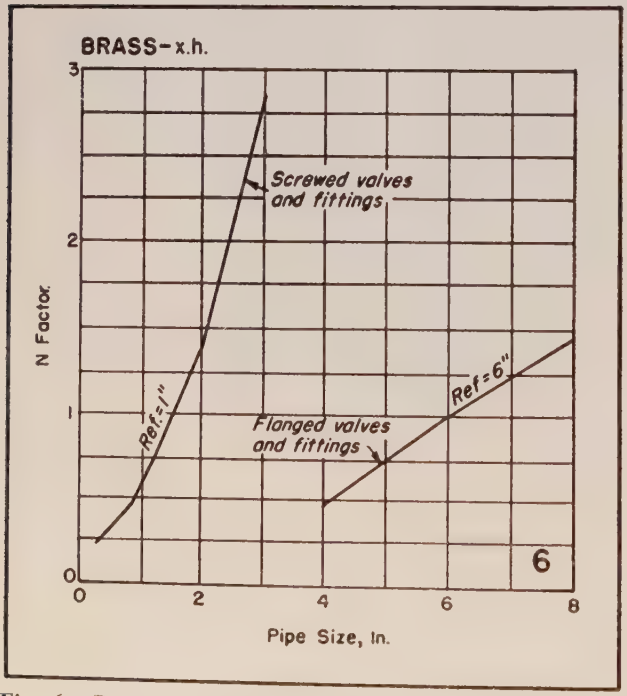

Fig. 6. Brass, red: Pipe, i.p.s., XH, 1/4 to 8 in., bare. Size 1/4 to 3 in., F brz. scr. 250 lb., V brz. scr. g. 300 lb. Size 4 to 8 in., F brs. fl. 250 lb., V brs. fl. g. 250 lb. cwp.

	1 1/2 in.			6 in.		
	M	L	T	M	L	T
P	$ 1.98	0.10	2.08	$ 20.10	0.55	20.65
F	2.50	1.50	4.00	270.00	20.00	290.00
V	15.00	2.00	17.00	330.00	15.00	345.00

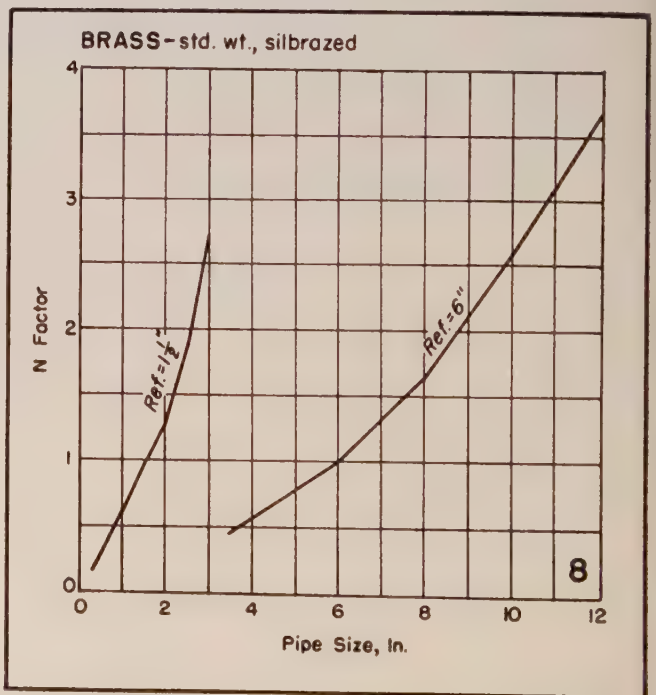

Fig. 8. Brass, red: Pipe, i.p.s., std. wt., 1/4 to 12 in., slb., bare. F brs. slb. Size to 3 in., V brz. slb., size 3 1/2 to 12 in. V brz. fl. wedge g. OS & Y; Fl. brs. 150 lb.

	1 1/2 in.			6 in.		
	M	L	T	M	L	T
P	$1.80	0.09	1.89	$ 13.50	0.45	13.95
F	4.00	1.50	5.50	66.00	5.50	71.50
V	7.00	1.50	8.50	250.00	17.00	267.00

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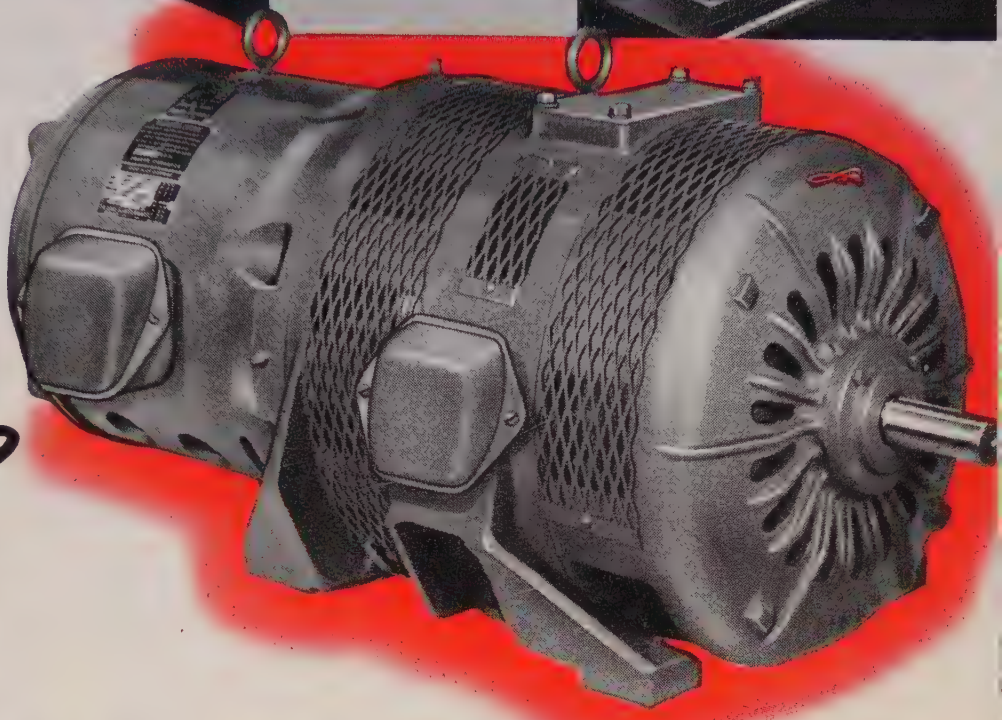

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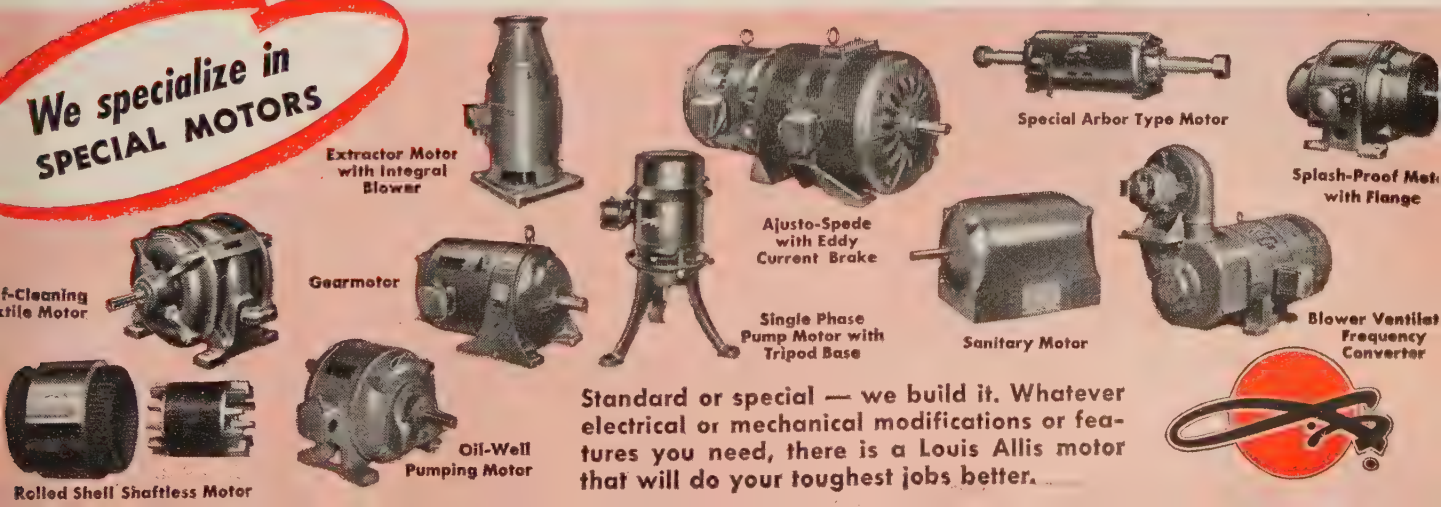

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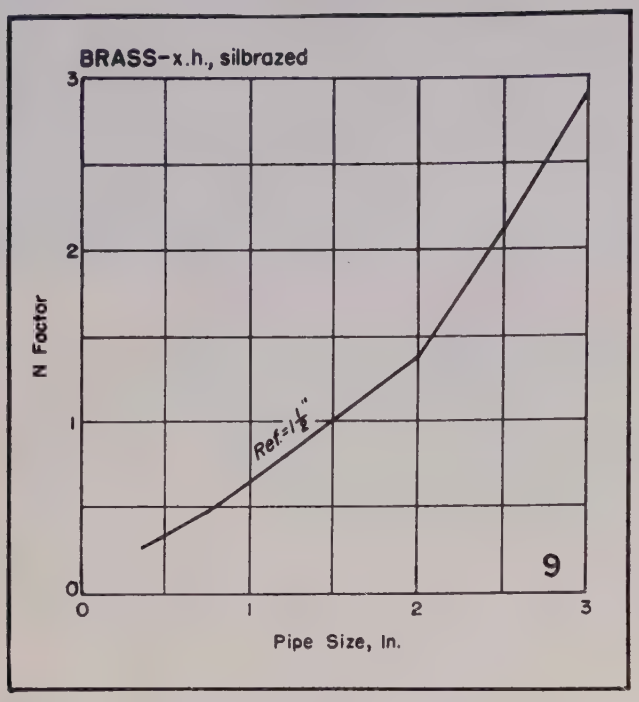

Fig. 9. Brass, red: Pipe, i.p.s., XH, 3/8 to 3 in., slb., bare. Fittings, brass, silbraze ends, 250 lb. Valves, bronze gate, silbraze ends, 300 lb.

	1½ in.		
	M	L	T
P	$ 2.54	0.12	2.66
F	11.00	1.50	12.50
V	20.00	1.50	21.50

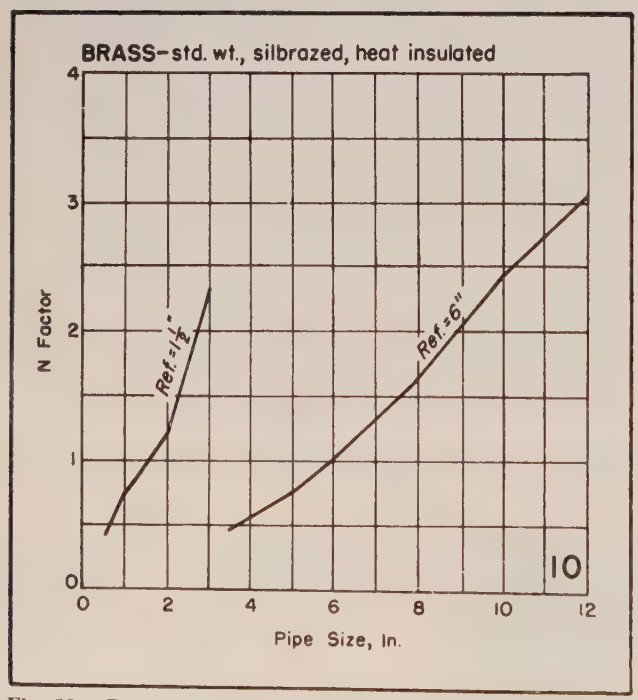

Fig. 10. Brass, red: Pipe, i.p.s., std. wt., 1/2 to 12 in., slb. Insulated 400°. Fittings and valves same as Fig. 8 for sizes to 3 in. and 3½ to 12 in. Insulated 85% mag. 400°

	1½ in.			6 in.		
	M	L	T	M	L	T
P	$2.27	0.30	2.57	$ 14.60	0.70	15.30
F	4.25	1.56	5.81	66.64	5.74	72.38
V	7.25	1.56	8.81	250.64	17.24	267.88

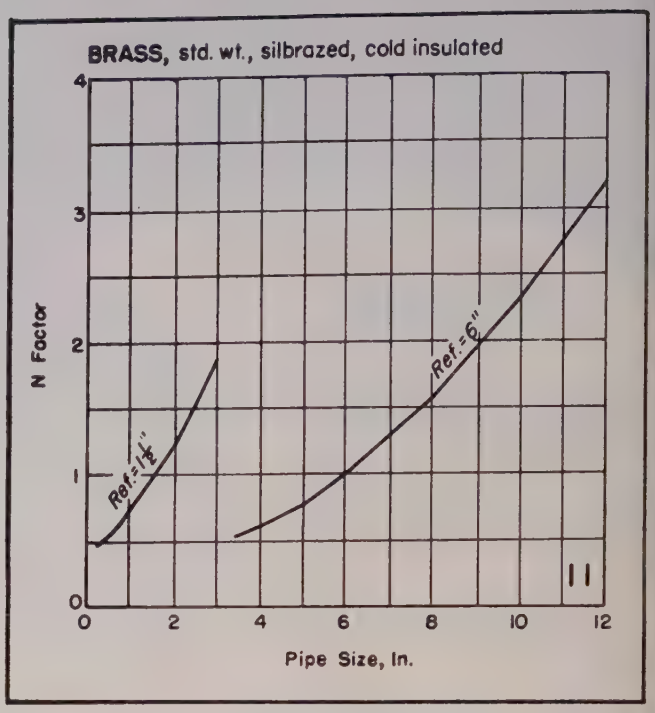

Fig. 11. Brass, red: Pipe, i.p.s., std. wt., 1/4 to 12 in., slb., insulated 0 to −25° F. Fittings and valves same as Fig. 8 sizes to 3 in. and 3½ to 12 in. Insulated S.B.T. cork

	1½ in.			6 in.		
	M	L	T	M	L	T
P	$ 3.77	1.19	4.96	$ 18.37	3.25	21.62
F	10.60	4.00	14.60	81.30	11.30	92.60
V	13.60	4.00	17.60	279.00	30.00	309.00

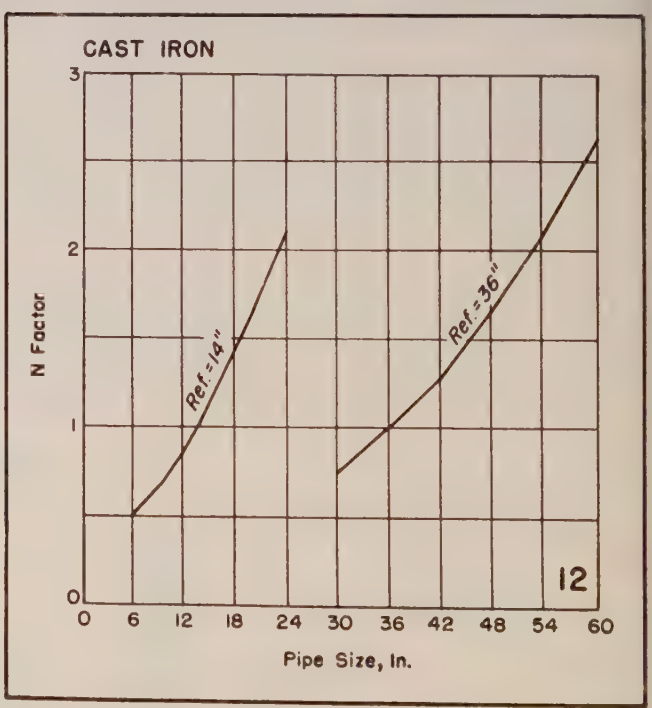

Fig. 12. Cast iron: Pipe, CI, B & S class C, tar-coated, 6 to 60 in. Fittings CI, B & S, class D. Valves, CI, brz. mounted O S & Y, fl. gate, 125 lb.

	14 in.			36 in.		
	M	L	T	M	L	T
P	$ 9.45	3.51	12.96	$ 27.60	21.90	49.50
F	101.00	41.00	142.00	600.00	37.00	737.00
V	360.00	185.00	545.00	3000.00	310.00	3310.00

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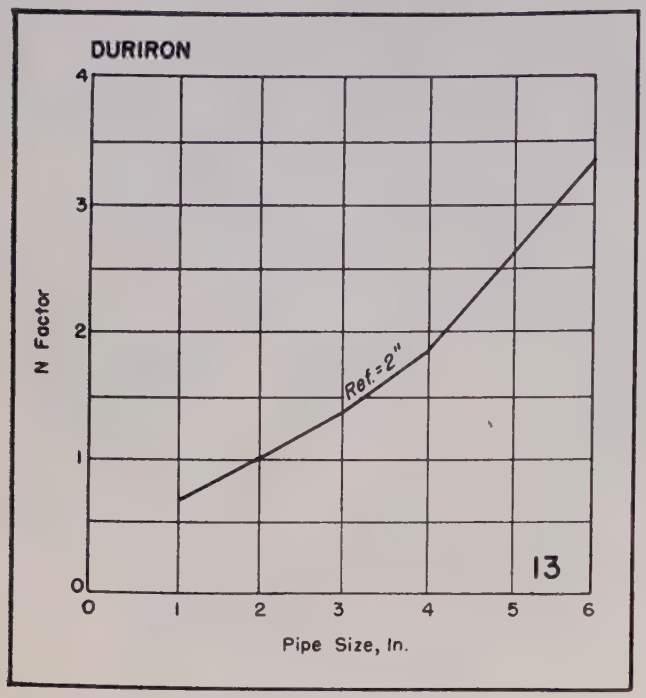


Fig. 13. Duriron: Pipe, Duriron, split fl., 1 to 6 in., bare, 3 ft. long to 1½ in., 4 ft. to 2 in., 5 ft. to 6 in. Fittings, DI split fl. Valves, DI lube. plug, straight-way, flanged

	2 in.		
	M	L	T
P	$ 5.48	1.70	7.18
F	14.20	19.00	33.20
V	60.00	15.00	75.00

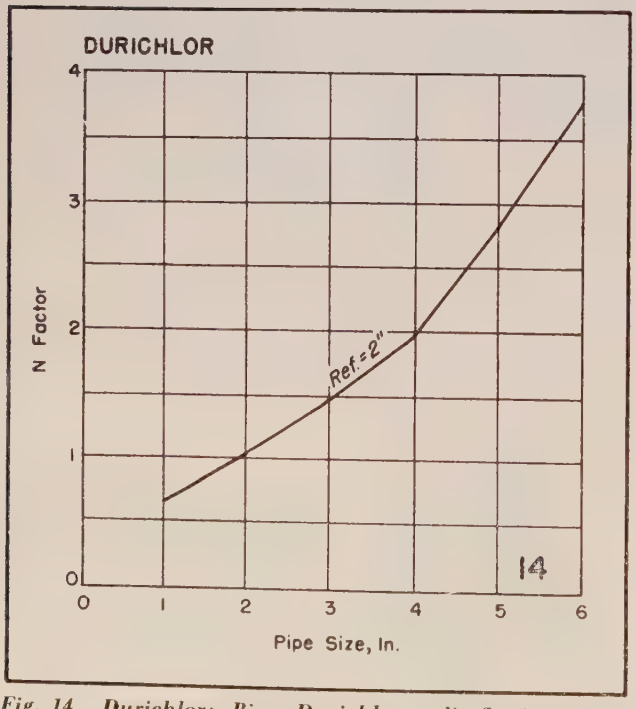


Fig. 14. Durichlor: Pipe, Durichlor, split fl., 1 to 6 in., bare. Fittings, Durichlor split flange. Valves, Durichlor lube. plug, straight-way flanged

	2 in.		
	M	L	T
P	$ 9.60	1.60	11.20
F	21.00	19.00	40.00
V	78.00	13.00	91.00

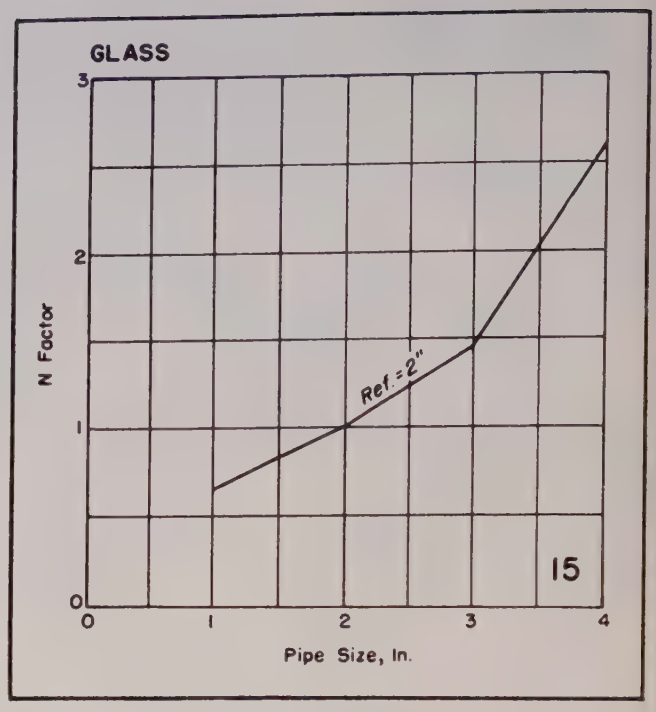


Fig. 15. Glass: Pipe, Pyrex glass, 10 ft. lengths, 1 to 4 in., bare. Fittings, Pyrex glass. Valves, Type 316 S.S. fl. g. Ser. 15. Flanges, CI

	2 in.		
	M	L	T
P	$ 1.42	0.21	1.63
F	22.00	17.00	39.00
V	74.00	11.00	85.00

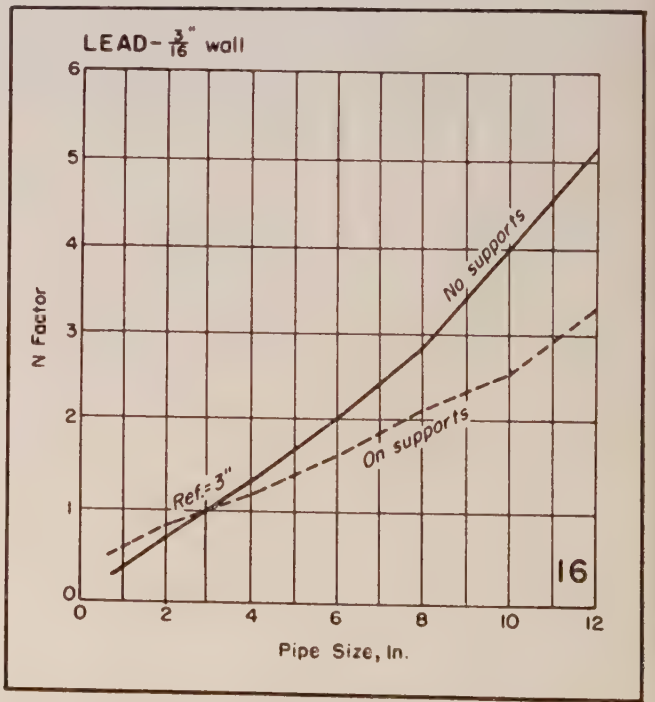
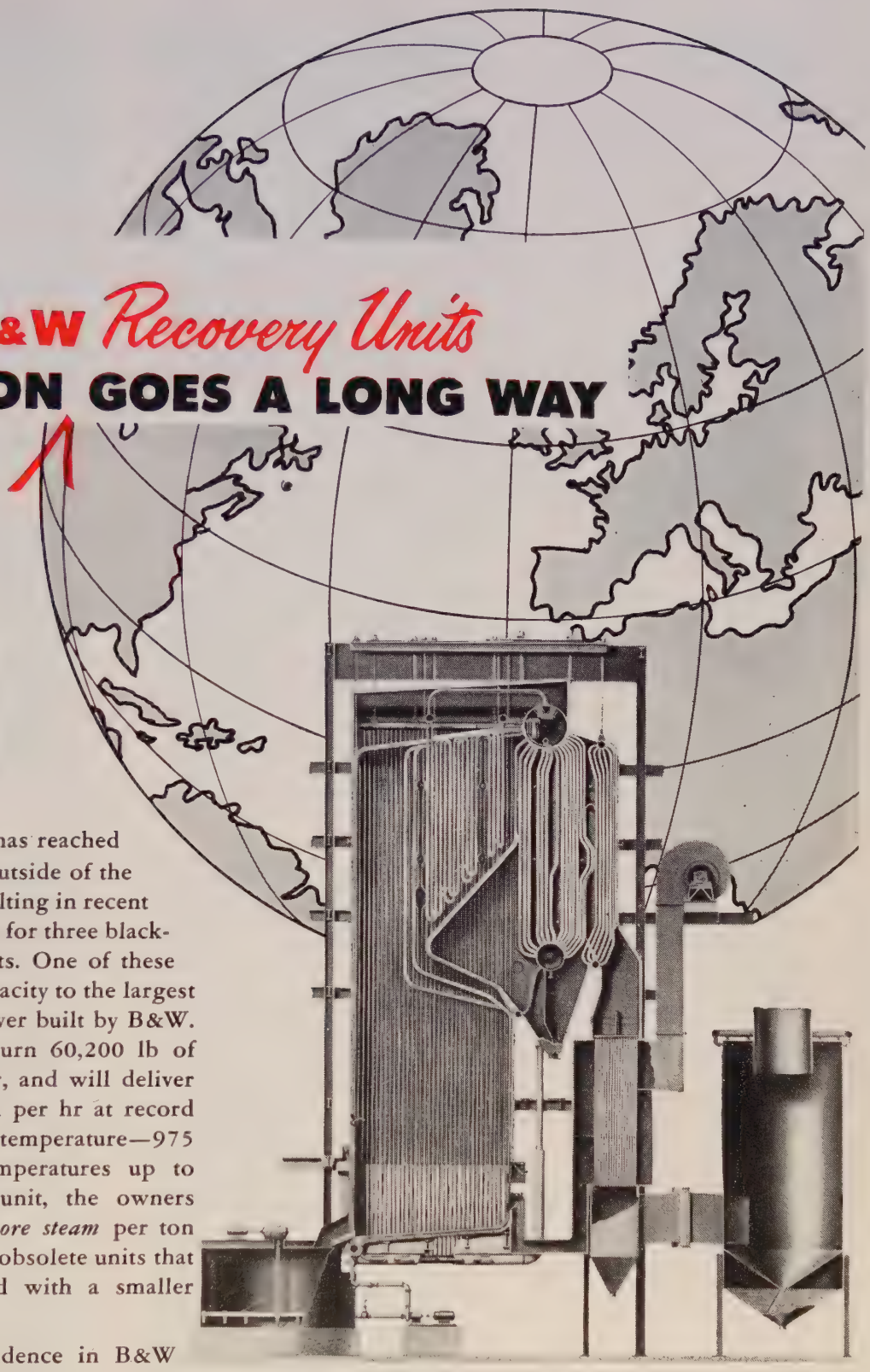


Fig. 16. Lead: Pipe 99.9% chem. Pb, 3/16-in. wall, 3/4 to 12 in. Fittings, Pb, plain ends. Valves, Pb, bolted bonnet Y type, fl. Flanges, Ser. 15 stl., slip-on

	3 in.		
	M	L	T
P*	$ 2.44	1.25	3.69*
F	6.00	7.00	13.00
V	55.00	7.00	62.00

* T = $6.99 for pipe on supports.

REPUTATION GOES A LONG WAY *of B&W Recovery Units*



B&W's reputation has reached over 5,000 miles outside of the United States...resulting in recent orders from Finland for three black-liquor recovery units. One of these will be equal in capacity to the largest black-liquor units ever built by B&W. It is designed to burn 60,200 lb of black liquor per hr, and will deliver 152,900 lb of steam per hr at record high pressure and temperature—975 psi (design) at temperatures up to 860 F. With this unit, the owners will get *one-third more steam* per ton than with the three obsolete units that it will replace, and with a smaller operating crew.

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Typical B&W Recovery Unit including a B&W Cyclone Evaporator

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BOILER DIVISION

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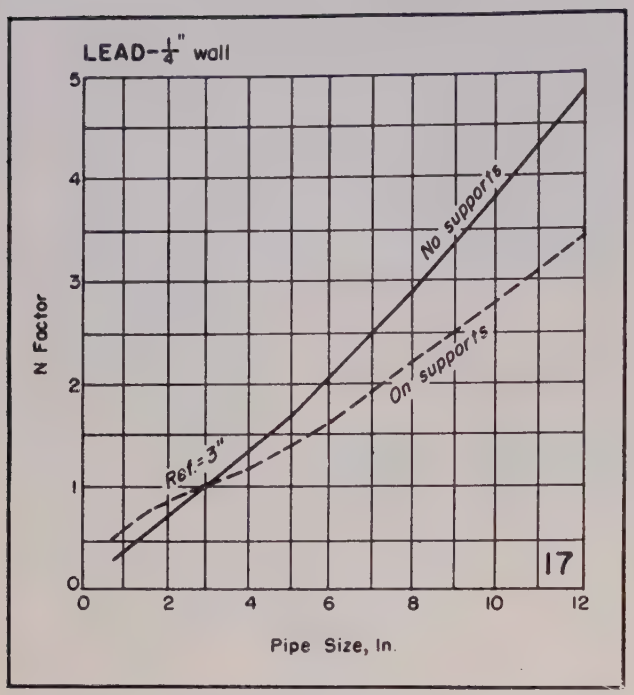


Fig. 17. Lead: Pipe 99.9% chem. Pb, 1/4-in. wall, 3/4 to 12 in. Lengths 10 ft. Fittings and valves same as Fig. 16. Unsupported pipe considered laid on existing supports or ground

	3 in.		
	M	L	T
P*	$ 3.30	1.68	4.98*
F	6.00	7.00	13.00
V	55.00	7.00	62.00

* T = $9.48 for pipe on supports.

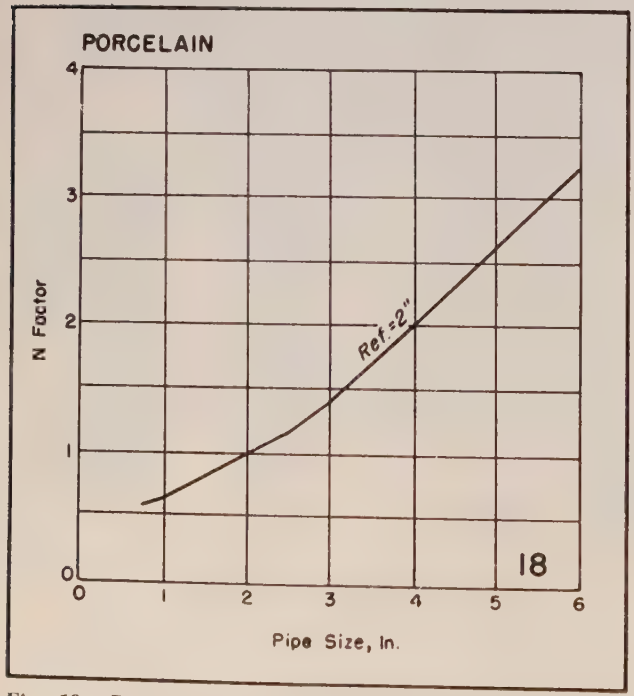


Fig. 18. Porcelain: Pipe, chemical porcelainware with flared ends, 5 ft. lengths, 3/4 to 6 in. Fittings and valves all chemical porcelainware

	2 in.		
	M	L	T
P	$ 2 35	2.20	4.55
F	9.00	7.00	16.00
V	60.00	5.00	65.00

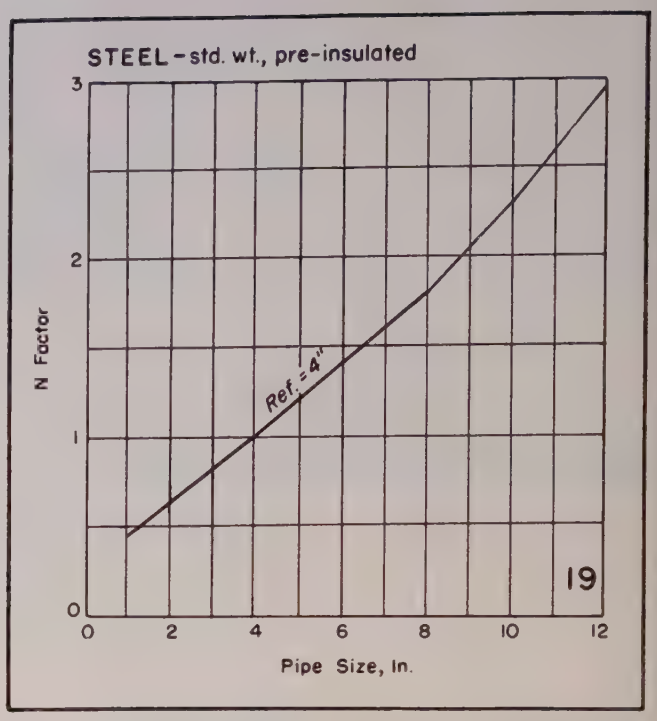


Fig. 19. Steel, preinsulated: Pipe, std. wt. seamless black, Ric-Wil, 1 to 12 in., insulated 1 1/2 in. for 300°F. F, std. wt. stl. welding. V, cast stl. fl. g. Ser. 15. Data from mfr.

	4 in.		
	M	L	T
P	$ 3.25	0.72	3.97
F	10.71	10.15	20.86
V	110.41	14.35	124.76

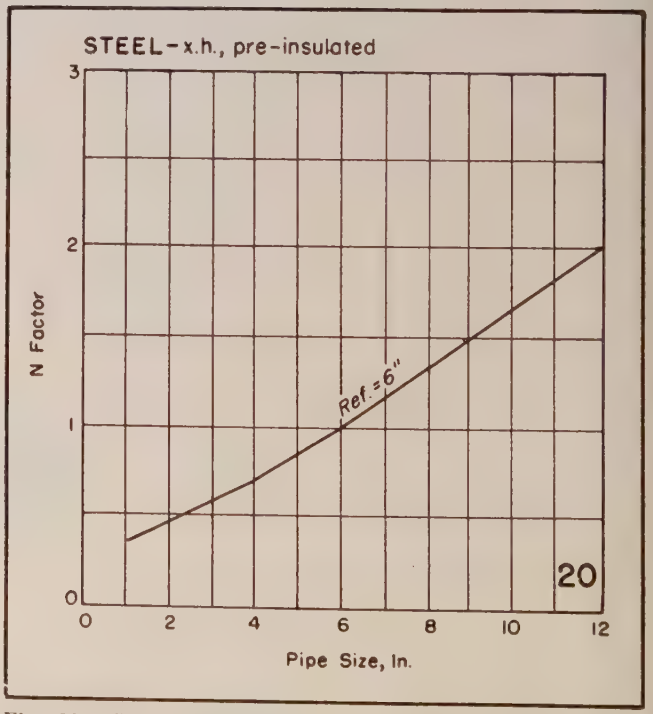
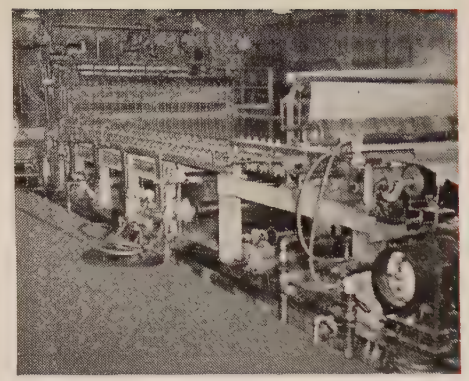
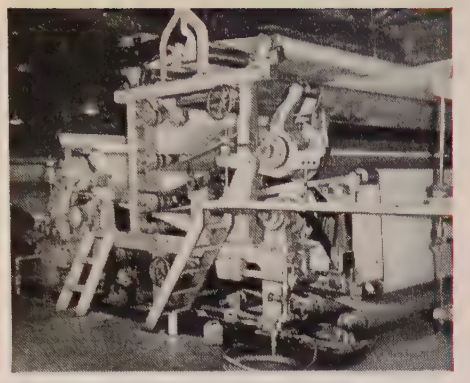
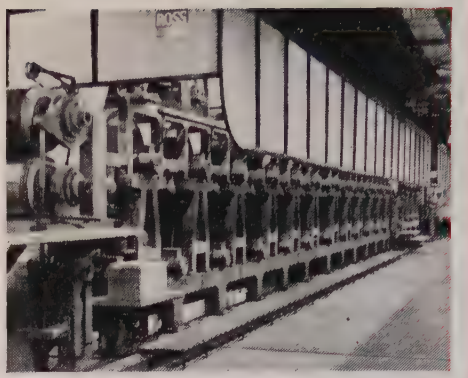
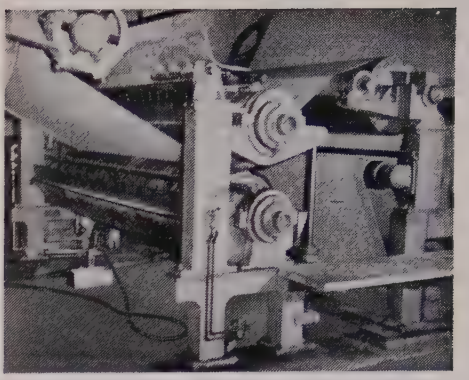
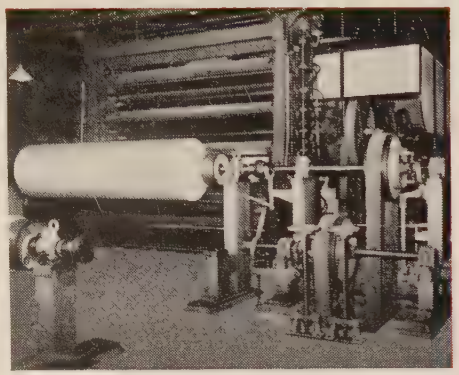
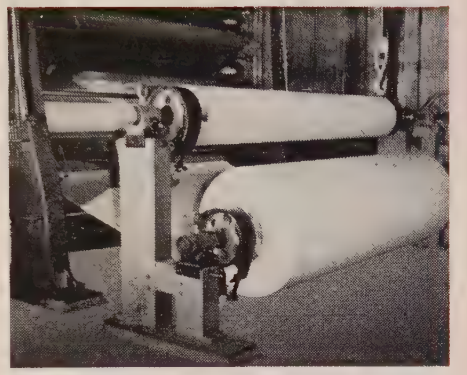
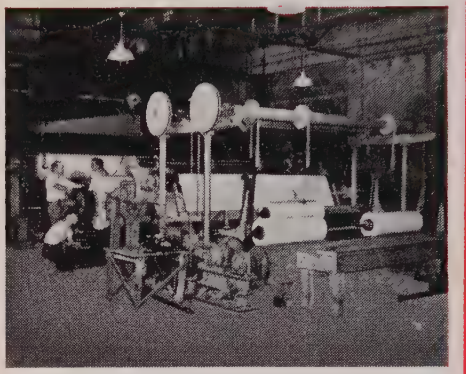
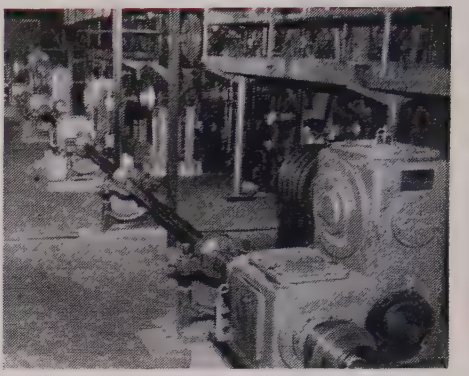


Fig. 20. Steel, preinsulated: Pipe XH, seamless black, Ric-Wil, 1 to 12 in., insulated 2 in. for 500°F. Fittings XH stl., wld. Valves, cast stl. fl. g. Ser. 30. Data from mfr.

	6 in.		
	M	L	T
P	$ 5.22	1.30	6.52
F	26.22	16.80	43.02
V	269.00	22.30	291.30

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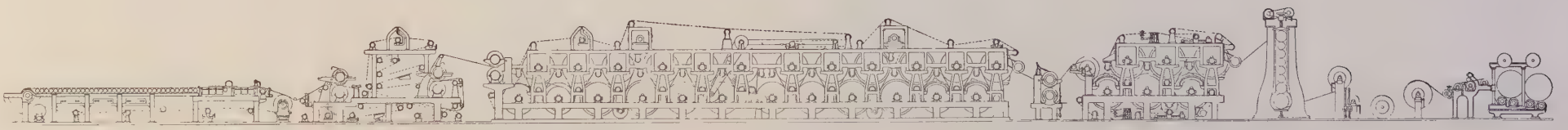

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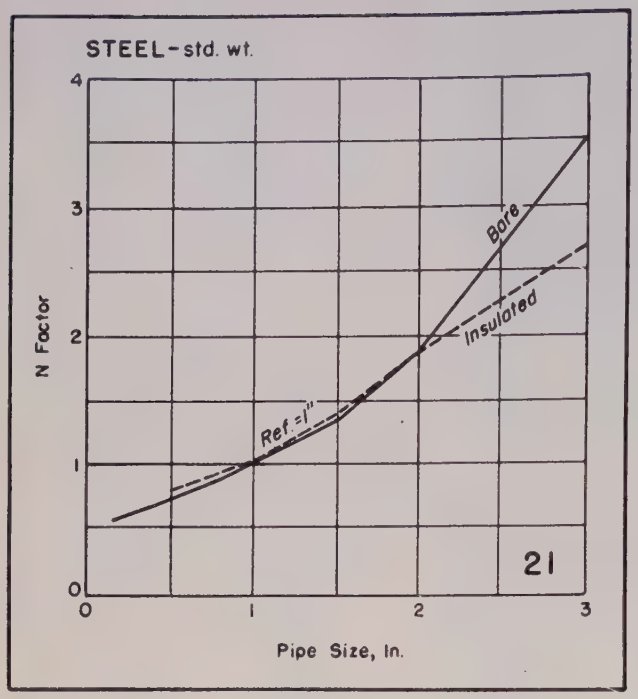


Fig. 21. Steel: Pipe, butt welded, std. wt. black, bare and 400° insulated, 1/8 to 3 in. F, fgd. stl. scr. 2000 lb. cwp. V, brz. g. scr. 200 lb. cwp. Insulated std. th. 85% mag.

	1 in., bare			1 in., 400°		
	M	L	T	M	L	T
P	$0.10	0.03	0.13	$0.42	0.22	0.64
F	1.50	3.00	4.50	1.50	3.00	4.50
V	8.00	3.00	11.00	8.00	3.00	11.00

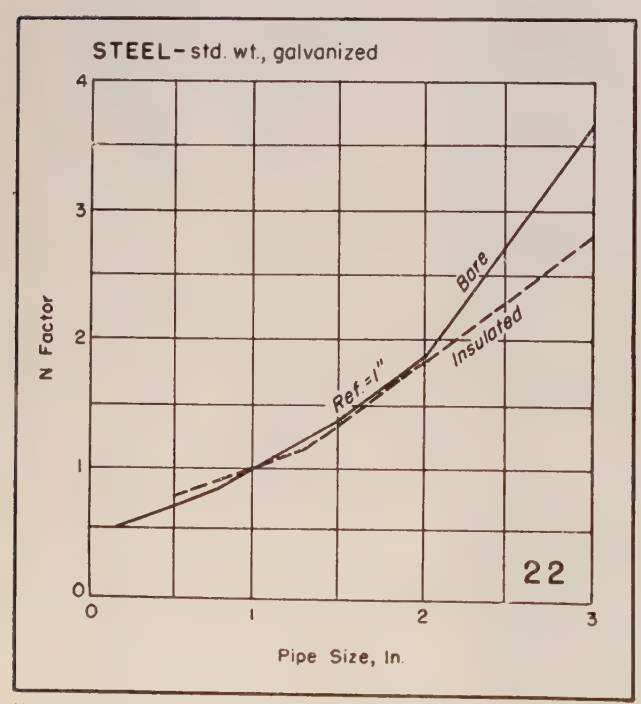


Fig. 22. Steel, galvanized: Pipe, butt welded, std. wt. galv., bare and 400° insulated, 1/8 to 3 in. F, mal. iron, scr. galv. V., brz. scr. g. 200 lb. cwp. Insulated std. th. 85% mag.

	1 in., bare			1 in., 400°		
	M	L	T	M	L	T
P	$0.15	0.05	0.20	$0.47	0.27	0.72
F	1.60	3.00	4.60	1.74	3.20	4.94
V	8.00	4.00	12.00	8.14	4.04	12.18

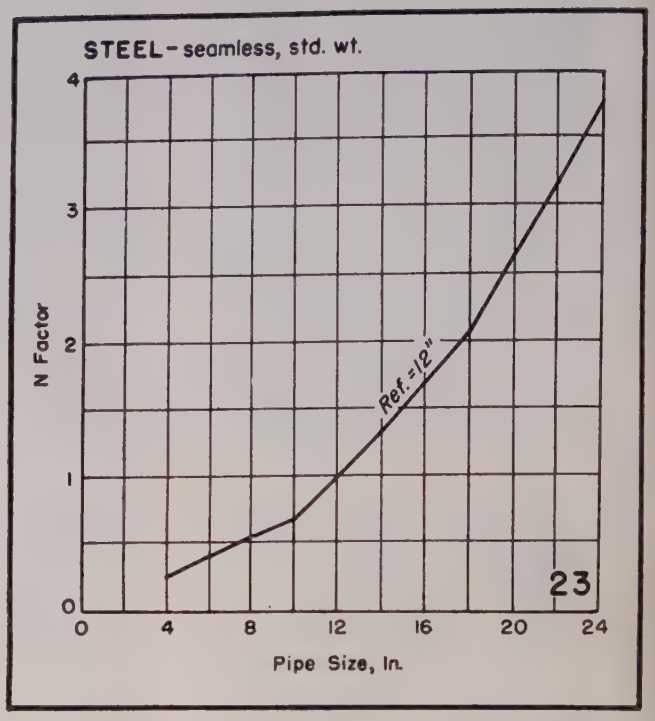


Fig. 23. Steel, seamless: Pipe, std. wt. black, bare, 4 to 24 in. Size 4 to 10 in., Sch. 40, Size 12 to 24 in., 0.375-in. wall. F std. wt. stl. wld. Fl. fgd., V cast stl. fl. g. Ser. 15

	12 in.		
	M	L	T
P	$ 4.00	0.96	4.96
F	95.00	18.00	113.00
V	535.00	70.00	605.00

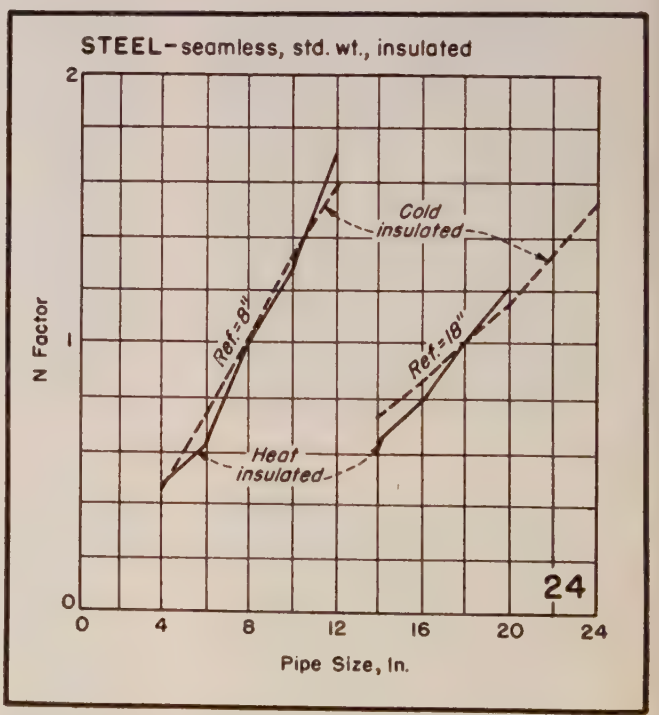
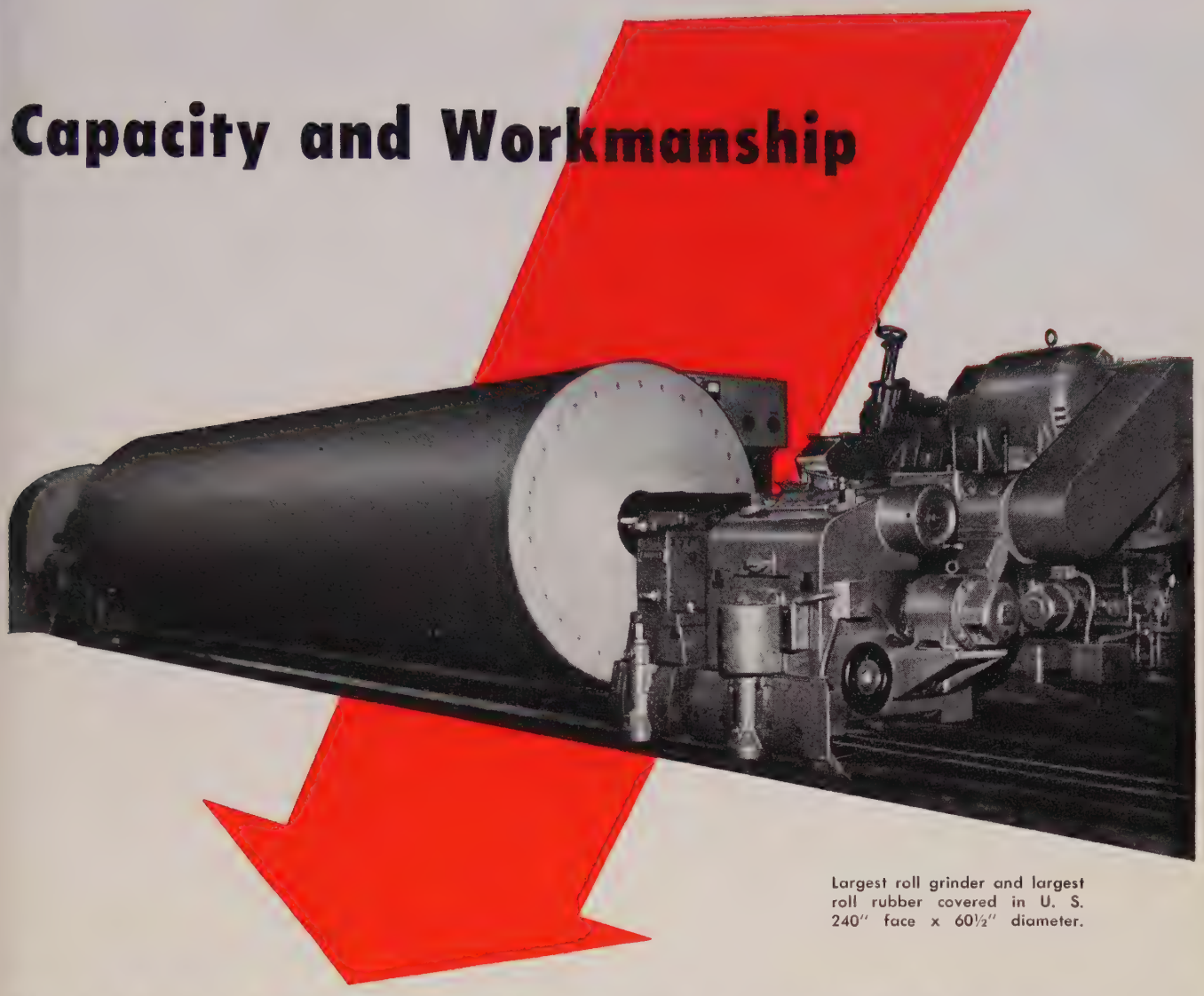


Fig. 24. Steel, seamless: 4 to 24 in., insulated 400°F. and 0 to −25°F. Pipe, fitting and valve all as in Fig. 23. Insulated 85% mag. 400° and heavy duty th. cork −25°

	8 in., 400° total[8]	18 in., 400° total[8]	8 in., −25° total[8]	18 in., −25° total[8]
P	$ 5.21	12.71	15.92	31.97
F	62.38	244.42	103.15	332.75
V	336.42	1507.00	417.80	1673.00

Capacity and Workmanship



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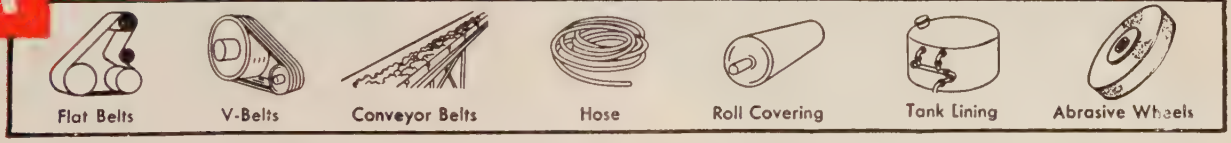

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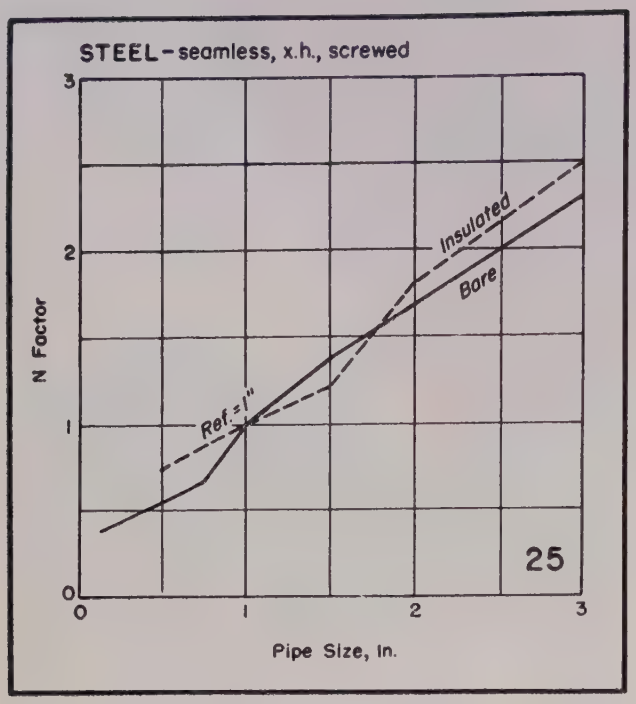

Fig. 25. Steel, seamless: Pipe, XH, black, bare and 800° F. insulated, 1/8 to 3 in. F fgd. stl. scr. 2000 lb. cwp., V fgd. stl. g. scr. 600 lb. cwp. Superex and 85% mag. 800°

	1 in., bare			1 in., 800°		
	M	L	T	M	L	T
P	$ 0.35	0.05	0.40	$ 1.00	0.35	1.35
F	1.70	3.00	4.70	2.02	3.01	5.03
V	32.62	4.00	36.62	32.89	4.06	36.95

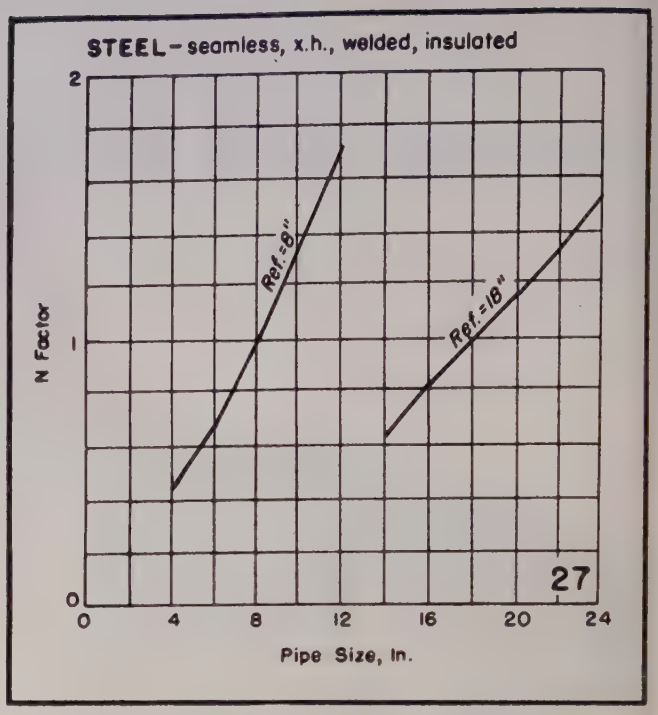

Fig. 27. Steel, seamless: 4 to 24 in., insulated 800°F. All pipe, fittings, valves same as Fig. 26. Insulation for 800° is 85% mag. and Superex

	8 in.			18 in.		
	M	L	T	M	L	T
P	$ 6.44	1.12	7.56	$ 14.26	3.33	17.59
F	67.00	26.00	93.00	266.20	42.50	308.70
V	406.00	50.00	456.00	1752.40	112.60	1864.00

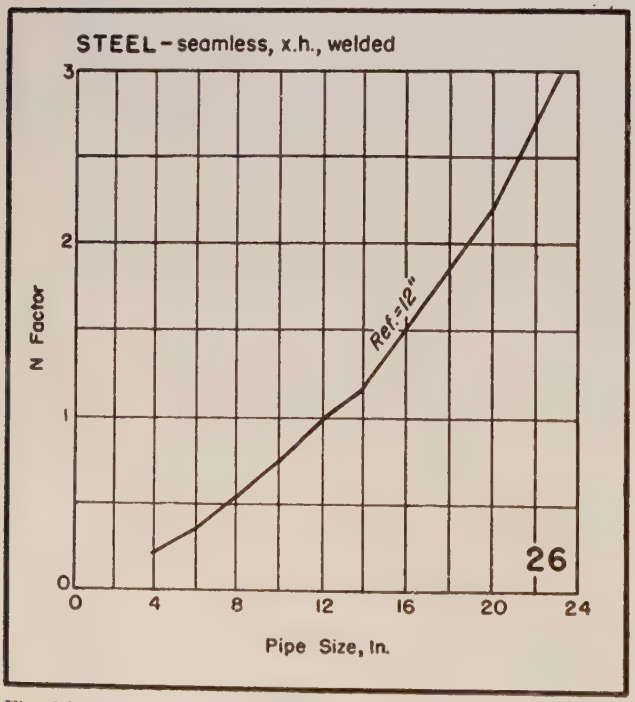

Fig. 26. Steel, seamless: Pipe, black, XH, bare, 4 to 24 in. Size 4 to 10 in., Sch. 80; size 12 to 24 in., 0.625 wall. F stl. XH wld. V cast stl. fl. g. Ser. 30. Fl. fgd. Ser 30, wld.

	12 in.		
	M	L	T
P	$ 4.62	1.37	5.99
F	145.00	34.00	179.00
V	773.00	80.00	853.00

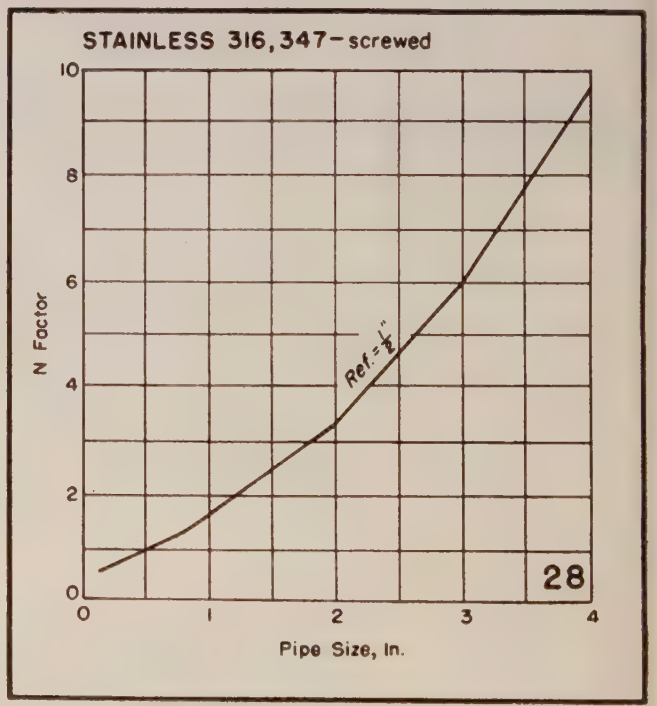

Fig. 28. Steel, stainless, types 316, 347: Pipe std. wt. bare, scr. joints, 1/8 to 4 in. Fittings and valves, same metal, 150 lb. screwed

	1/2 in.		
	M	L	T
P	$ 3.15	0.04	3.19
F	1.85	2.00	3.85
V	25.50	3.00	28.50

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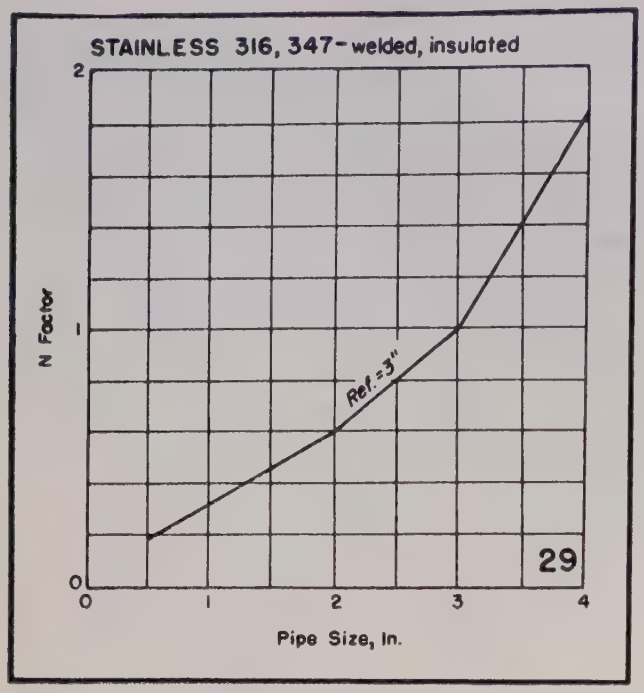

Fig. 29. Steel, stainless, types 316, 347: 1/2 to 4 in., insulated 400°F. Pipe, fittings and valves all same specifications as Fig. 28. Insulated 85% mag. 400°F.

	3 in.		
	M	L	T
P	$ 19.44	0.61	20.05
F	20.54	1.95	22.49
V	142 28	4.11	146.39

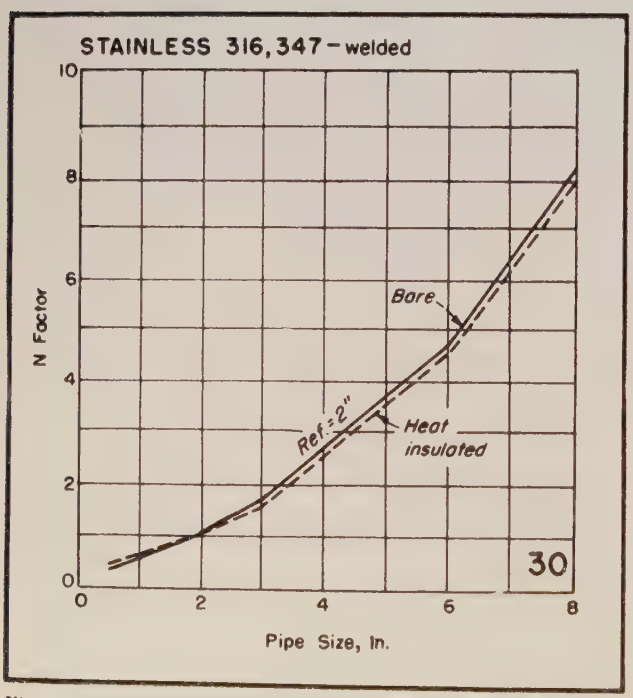

Fig. 30. Steel, stainless, types 316, 347; Pipe std. wt. 1/2 to 8 in. bare and insulated. Size to 4 in. F scr. V 150 lb. scr. Size 6 to 8 in. F wld. V fl. Ser. 15 same metal. Insulated 85% mag.

	2 in., bare			2 in., 400°		
	M	L	T	M	L	T
P	$10.85	0.13	10.98	$11.27	0.41	11.68
F	23.00	4.37	27.37	23.23	4.86	28.19
V	95.00	4.24	99.24	95.83	3.98	99.81

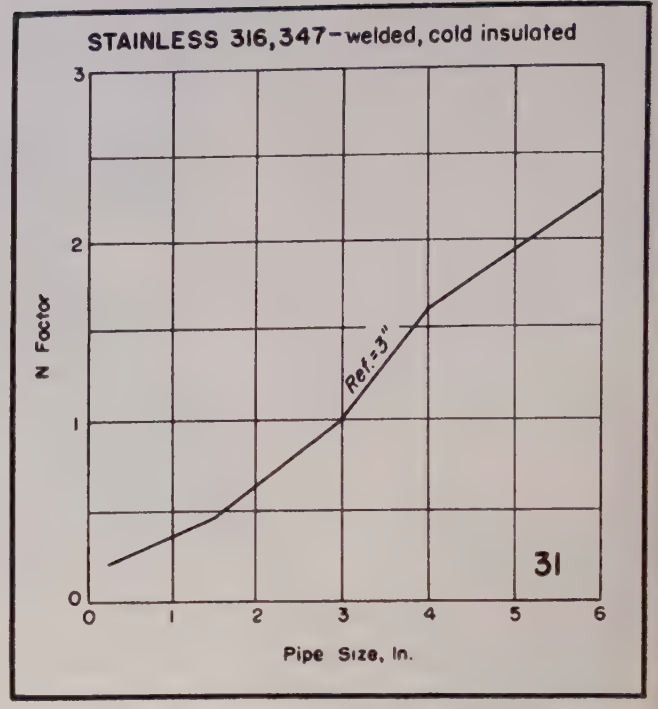

Fig. 31. Steel, stainless, types 316, 347: Pipe std. wt., 1/4 to 6 in. insulated 0 to −25°F. Fittings and valves same as Fig. 30. Insulation S.B.T. cork 0 to −25°

	3 in.		
	M	L	T
P	$ 23.05	1.55	24.60
F	33.20	8.40	41.60
V	159.00	10.45	169.45

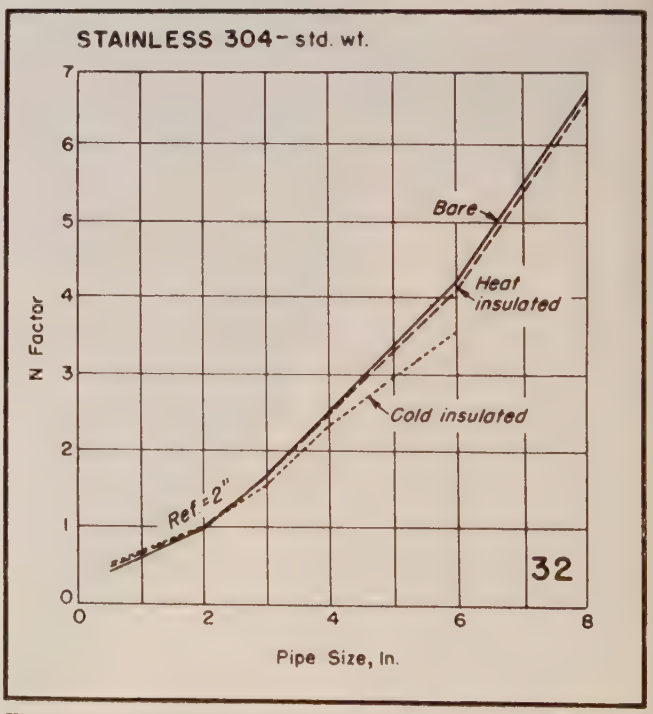

Fig. 32. Steel, stainless, type 304: Pipe, std. wt., wld., bare and insulated. F type 304 std. wt. wld. V type 304 fl. g. Ser. 15. Insulated 85% mag. 400°, S.B.T. cork, 0 to −25°

	2 in., bare total[10]	2 in., hot total[10]	2 in., cold total[10]
P	$ 8.08	8.56	12.92
F	25.00	25.41	35.52
V	88.00	88.41	102.50

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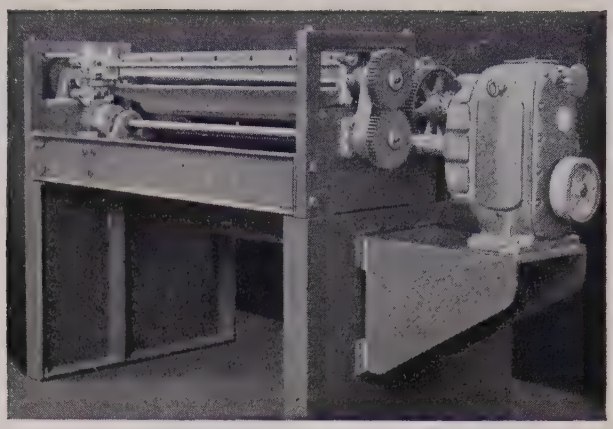

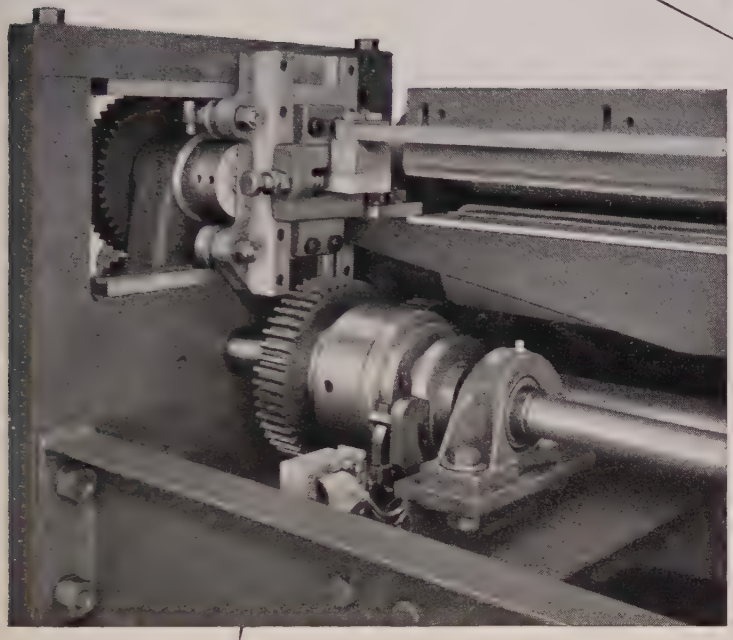

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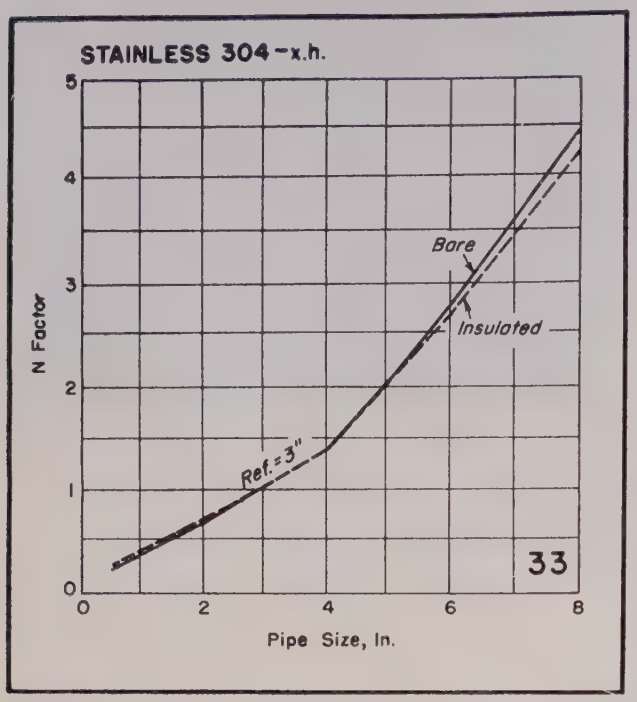

Fig. 33. Steel, stainless, type 304: Pipe, XH, wld., 1/2 to 8 in., bare and 800° insulated F type 304 XH wld. V type 304 Ser. 30 fl. g. Insulated 85% mag. and Superex 800°F.

	3 in., bare			3 in., 800°		
	M	L	T	M	L	T
P	$ 18.07	0.13	18.20	$ 19.47	1.33	20.80
F	53.50	7.00	60.50	54.87	7.34	62.21
V	268.00	16.00	284.00	267.30	15.70	283.00

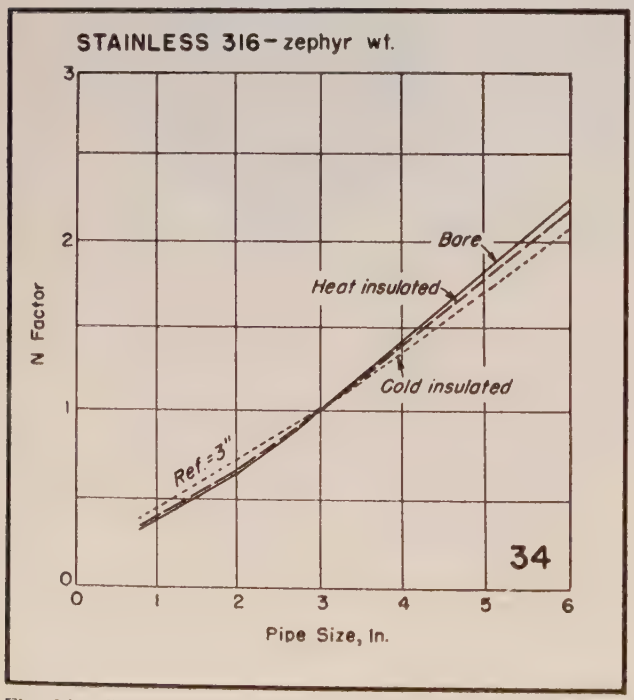

Fig. 34. Steel, stainless, type 316: Pipe, zephyr wt. wld., 3/4 to 6 in., bare and insulated F 136 zephyr wt. wld. V 316 Ser. 15 fl. g. Fl. 316 Ser. 15 wld. Insulated 85% mag., S.B.T. cork

	3 in., bare total[3]	3 in., hot total[3]	3 in., cold total[3]
P	$ 6.19	7.09	11.64
F	13.00	14.10	32.60
V	125.00	125.95	148.45

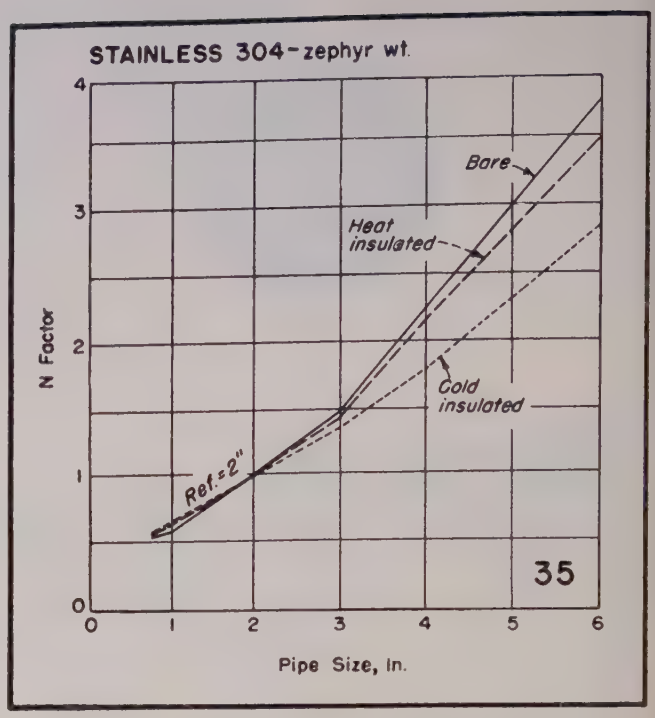

Fig. 35. Steel, stainless, type 304: Pipe, zephyr wt. wld., 3/4 to 6 in., bare and insulated. Fittings, valves, flanges as in Fig. 34 except type 304. Insulated 85% mag. and S.B.T. cork

	2 in., bare total[4]	2 in., hot total[4]	2 in., cold total[4]
P	$ 2.53	3.29	7.36
F	8.00	8.82	18.50
V	90.00	90.82	104.50

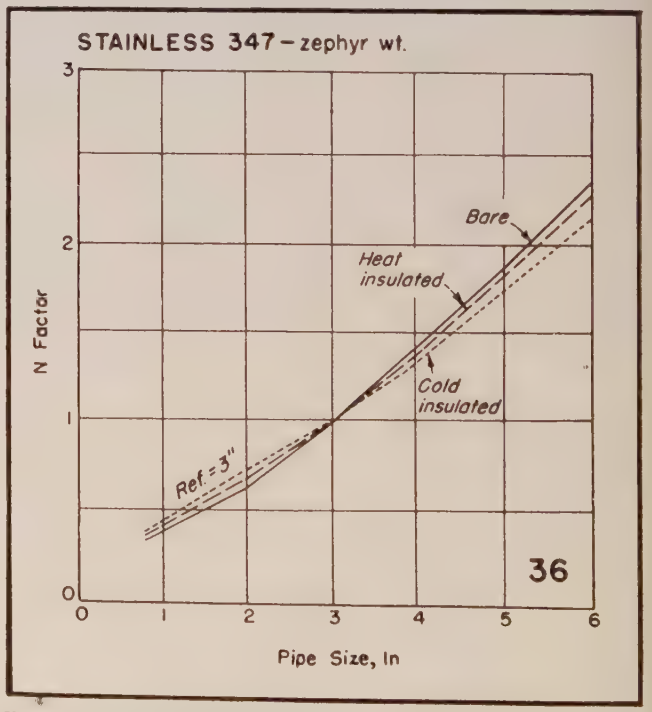

Fig. 36. Steel, stainless, type 347: Pipe, zephyr wt. wld., 3/4 to 6 in., bare and insulated. Fittings, valves, flanges, and insulation as in Fig. 34, except S.S. type 347

	3 in., bare total[5]	3 in., hot total[5]	3 in., cold total[5]
P	$ 5.51	6.41	10.96
F	15.00	15.93	34.60
V	125.00	125.98	148.45

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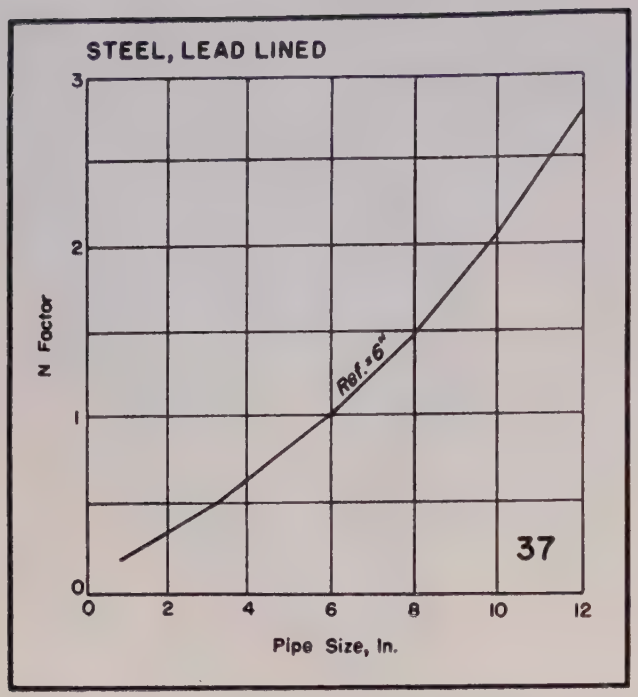


Fig. 37. Steel, lead lined: Pipe, std. wt. homogeneous lined avg. 3/16 in. th., Fl. made on, 3/4 to 12 in. F ll. stl. fl. Ser. 15. V stl. fl. g. ll. Ser. 15. Fl. stl. ll. Ser.

	6 in.		
	M	L	T
P	$ 15.40	0.43	15.83
F	130.00	20.00	150.00
V	320.00	15.00	335.00

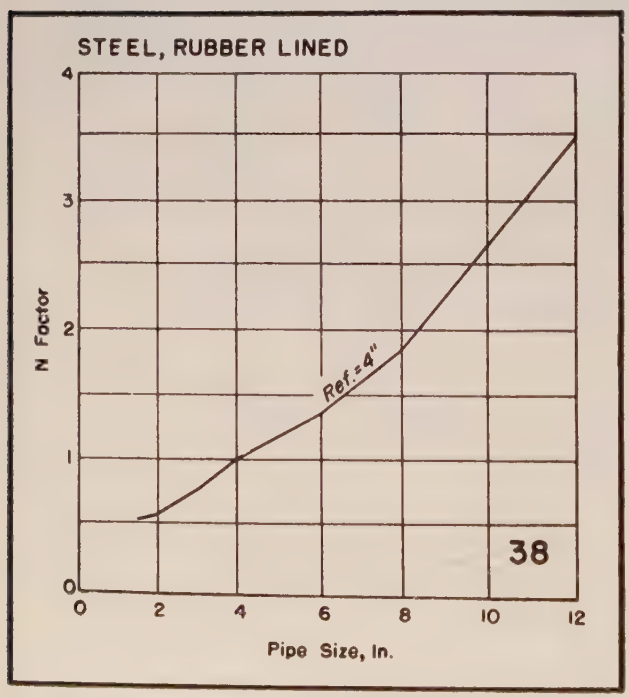


Fig. 38. Steel, rubber lined: Pipe, std. wt. lined 3/16 in. th., Fl. made on, 1 1/2 to 12 in. F CI 125 lb. rl., V std. Ace rl. fl. gate

	4 in.		
	M	L	T
P	$ 6.33	0.35	6.68
F	41.00	13.00	54.00
V	105.00	9.00	114.00

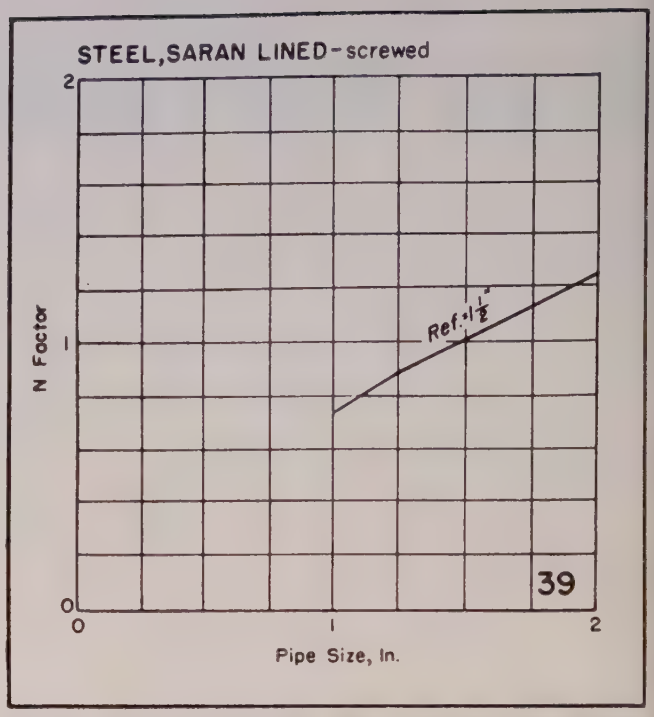


Fig. 39. Steel, Saran lined: Pipe, std. wt. Saran lined, scr., 1 to 2 in. Fittings CI Saran lined, screwed. Valves, Saran lined stl. plug, flanged, Series 15

	1 1/2 in.		
	M	L	T
P	$ 2.20	0.11	2.31
F	11.00	2.00	13.00
V	60.00	4.00	64.00

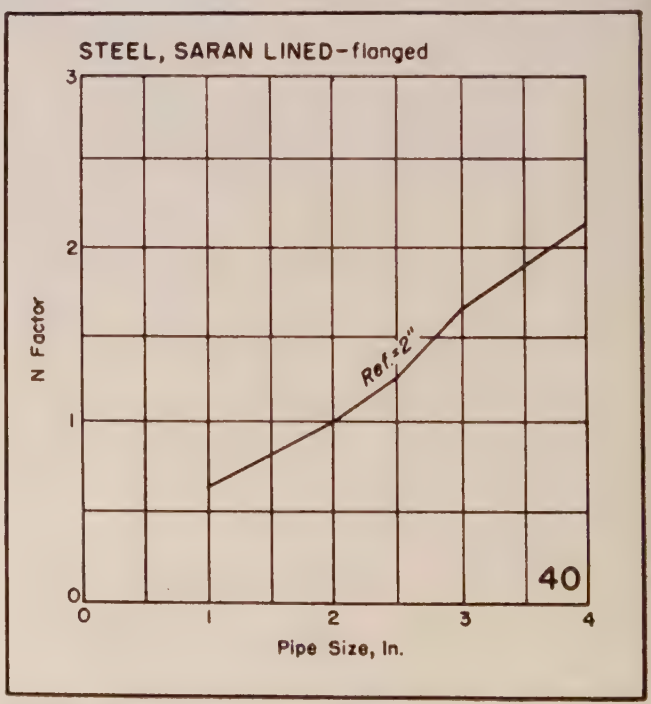
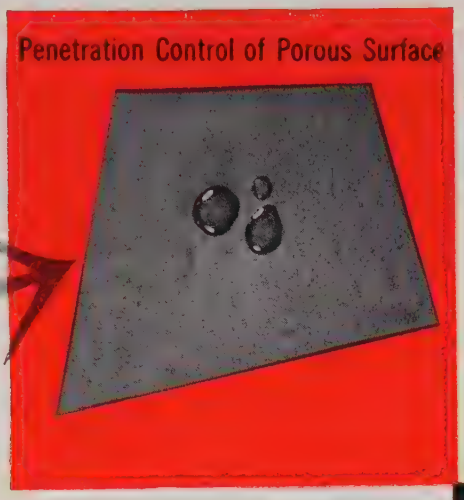


Fig. 40. Steel, Saran lined: Pipe, std. wt. Saran lined, fl., 10-ft. lengths, 1 to 4 in. Fittings CI Saran lined, 125 lb. flanged. Valves, stl. plug Saran lined, flanged, Series 15

	2 in.		
	M	L	T
P	$ 2.80	0.25	3.05
F	25.00	7.00	32.00
V	70.00	6.00	76.00

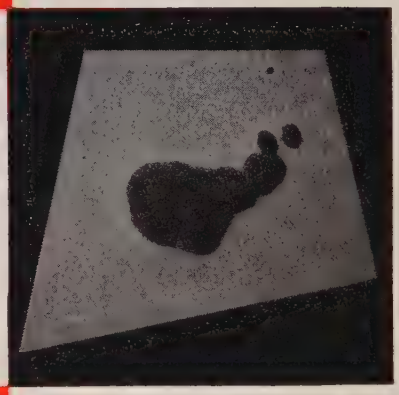
the blotter that WON'T BLOT!



This unretouched photograph shows a 1% solution of KELSIZE twenty minutes after being puddled on blotter. Note how solution remains on surface of blotter. This test illustrates that KELSIZE is an excellent material for controlling penetration and strike through of aqueous solutions, thus increasing the efficiency of adhesive or surface sizing solutions by retaining them at the area of application.

proof THAT YOU REGULATE SURFACE DENSITY AND PENETRATION... *precisely and effectively!*

Here is unretouched photograph of water, without KELSIZE, on piece of same blotter, taken seconds after water was placed on blotter. Note how water has immediately passed into blotter compared to controlled penetration of KELSIZE solution.



kelsize *and* kelgin

superior surface control agents

Due to their film forming properties, KELSIZE and KELGIN effectively control penetration of adhesives, starch solutions, or any water base solution.

KELSIZE and KELGIN®

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Footnotes to cost tables:

(1) Detailed costs for Fig. 24.

	8 in., 400°			18 in., 400°		
	M	L	T	M	L	T
P	$4.23	0.98	5.21	$10.76	1.95	12.71
F	41.00	31.28	62.38	203.18	41.24	244.42
V	296.00	40.38	336.42	1396.00	111.00	1507.00

	8 in., 0 to −25°			18 in., 0 to −25°		
	M	L	T	M	L	T
P	$11.53	4.39	15.92	$23.14	8.83	31.97
F	70.50	32.65	103.15	267.00	65.75	332.75
V	355.00	62.80	417.80	1521.00	152.00	1673.00

(2) Detailed costs for Fig. 32.

	2 in., bare			2 in., hot		
	M	L	T	M	L	T
P	$7.95	0.13	8.08	$8.22	0.34	8.56
F	20.00	5.00	25.00	20.33	5.08	25.41
V	80.00	8.00	88.00	80.33	8.08	88.41

	2 in., cold		
	M	L	T
P	$11.45	1.47	12.92
F	27.70	7.82	35.52
V	90.35	12.15	102.50

(3) Detailed costs for Fig. 34

	3 in., bare			3 in., 400°		
	M	L	T	M	L	T
P	$6.09	0.10	6.19	$6.43	0.66	7.09
F	8.00	5.00	13.00	8.50	5.60	14.10
V	115.00	10.00	125.00	115.50	10.55	125.95

	3 in., 0 to −25°		
	M	L	T
P	$9.88	1.76	11.64
F	22.00	10.60	32.60
V	131.45	17.00	148.45

(4) Detailed costs for Fig. 35.

	2 in., bare			2 in., 400°		
	M	L	T	M	L	T
P	$2.45	0.08	2.53	$2.72	0.57	3.29
F	4.00	4.00	8.00	4.33	4.49	8.82
V	82.00	8.00	90.00	82.33	8.49	90.82

	2 in., 0 to −25°		
	M	L	T
P	$5.95	1.41	7.36
F	12.00	6.50	18.50
V	92.35	12.15	104.50

(5) Detailed costs for Fig. 36.

	3 in., bare			3 in., 400°		
	M	L	T	M	L	T
P	$5.41	0.10	5.51	$5.75	0.66	6.41
F	9.00	6.00	15.00	9.37	6.54	15.91
V	115.00	10.00	125.00	115.37	10.61	125.98

	3 in., 0 to −25°		
	M	L	T
P	$9.32	1.64	10.96
F	22.35	12.25	34.60
V	131.70	16.65	148.45

Hot water for pulp washing

uncontaminated . . . at the desired temperature

Recover heat from steam released in the digester blow tank with a Swenson Surface Condenser! Its operation is automatic and synchronized with blowing cycles. You'll get *clean* hot water at the desired temperature for pulp washing.

Let a Swenson Engineer help you arrange a condenser system to meet your specific needs!

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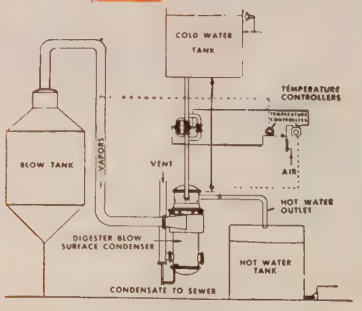
TALK WITH A SWENSON ENGINEER

HE WILL RECOMMEND THE RIGHT EQUIPMENT



Flow diagram shows general arrangement of Blow Condenser System

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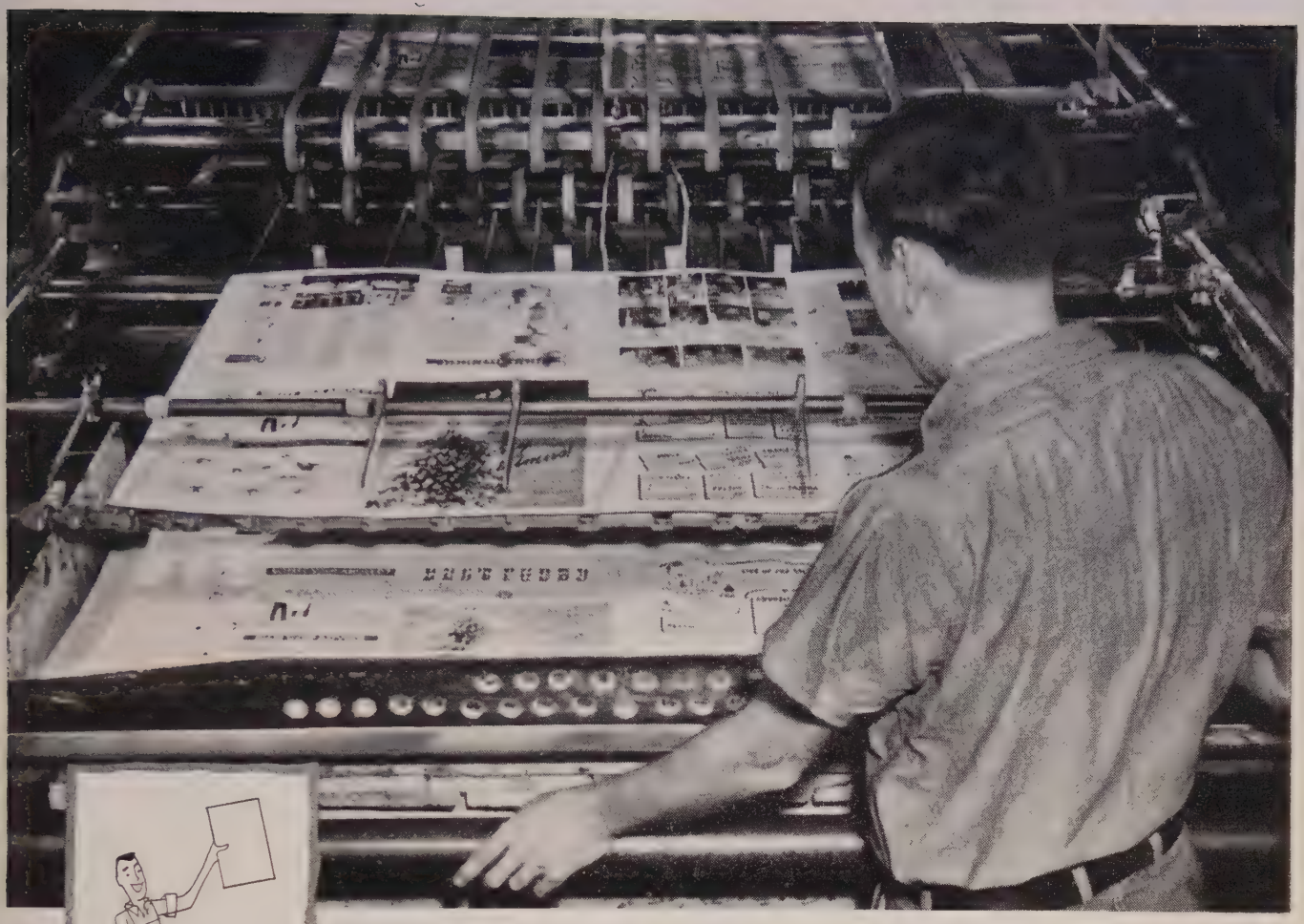
Proved Engineering for the Process Industries
SINCE 1889

A Division of WHITING Corporation



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These remarkable results are due to the porous diatomaceous structure and excellent suspension properties of Celite . . . two factors which increase opacity through high retention of the hiding pigments and the Celite powder itself.

In addition to reducing "show-through," Celite also improves ink receptivity because its absorptive capacity is higher than that of ordinary wood pulps . . . and far greater than that of any other filler regularly used in paper.

Other ways in which Celite helps you turn out a more printable, more readable paper are by reducing low angle sheen and giving the desired high brightness. And from a production standpoint, Celite can save you valuable man-hours and equipment down-time by controlling the pitch that comes from having to use green wood for pulp.

Why not ask a Celite Engineer to visit your mill and make on-the-spot recommendations for the profitable and economical use of Celite. Just write to Johns-Manville, Box 60, New York 16, New York. In Canada, 199 Bay Street, Toronto 1, Ontario. No cost or obligation.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

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Johns-Manville CELITE PRODUCTS

FOR THE PAPER INDUSTRY

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None of the usual cost indexes applies specifically to piping costs. The Marshall and Stevens indexes of comparative equipment costs regularly published probably offer a fair indicator of piping cost variations. Some engineers use the *Engineering News-Record* construction cost index, either as is or with modifications developed by the user. It is likely, however, that none of the various index series published by government bureaus and other organizations in the monthly *Survey of Current Business* is a particularly good indicator for pipe. So far as the author knows, only the privately circulated Handy Index of Public Utility Costs contains an actual piping cost index.

Whichever method is employed, the use of the N factor charts is exactly the same. It is first necessary to calculate the cost of the reference string as so many feet of pipe, so many fittings, and so many valves. A manifold can be handled as a string. The reference size is that size for which the N factor on the applicable chart is unity. Then the cost in place, for any other comparable string of the same kind and class of pipe, but of a different size, is equal to the cost of the reference string times the N factor for the size in question. As an example:

Taking a cold-insulated aluminum line, as described in Fig. 2, what will be the cost of a string consisting of 500 ft. of 6-in. pipe containing four fittings and three valves, insulated for 0 to −25°F.? Assume that the July,1949, data will be satisfactory without modification. Then, for the 4-in. reference size, 500 ft. of pipe plus four fittings plus three valves will come to $500 \times 9.42 + 4 \times 45.50 + 3 \times 220.75 = \$4710 + 182 + 662.25 = \$5554.25$. Since the N factor for the 6-in. size is 1.640, then the cost of the string in 6-in. pipe will be $\$5554.25 \times 1.640 = \$9109$. And that is all there is to it!

Estimating Data for Piping Labor Costs

LOUIS L. MRACHEK

During the past ten years, it has become increasingly difficult to estimate piping costs with any degree of accuracy. Therefore, we believe that a quick means of estimating these costs would be an invaluable guide to the plant engineer. We have endeavored to set up a table with factoring information for the purpose of estimating labor costs in the fabrication and erection of welded or flanged piping. This article will be confined to the costs necessary to fabricate and erect steel, aluminum, and stainless steel piping.

In setting up a table of this type, certain variables must have base costs. These are set forth as follows:

Pipefitters	$2.50 per hr.
Foremen	$2.75 per hr.
Superintendent	$3.00 per hr.

Under the procedure, the owner will furnish all materials such as pipe, valves, and fittings, but labor unit price shown below will include miscellaneous supplies such as welding rod, tools, rigging, trucks, and other equipment required. Fabrication costs covering butt welds or flanged welds in piping of 150 lb. pressure or less *per weld* will be as follows:

Pipe diameter, in.	*Butt weld*	*S.O. flange weld*	*Pipe diameter, in.*	*Butt weld*	*S.O. flange weld*
1 or less	2.58	3.10	10	28.44	38.16
1½	3.88	4.65	12	33.39	40.84
2	5.18	6.19	14	39.81	47.64
3	7.75	9.29	16	45.50	54.45
4	10.34	12.38	18	51.18	61.26
5	12.93	15.48	20	56.87	68.07
6	15.51	18.56	24	66.04	81.68
8	22.75	27.23	30	85.31	102.09

Figures are net if welded by arc or acetylene.
Screwed joints 25% of above.
Add 50% to the above for Heliarc welding of aluminum and stainless steel.

Should the necessity of estimating welding costs arise on sizes not included above, the cost should be calculated on the basis of $2.60 per diameter inch. On piping systems above the 150-lb. class add 25% for extra heavy pipe and 50% for double extra heavy.

Estimated erection cost will be calculated as follows (the following figures are based on a cost *per foot* of pipe):

Diameter, in.	*Height, 10 ft. or less*	*Height, above 10 ft.*
Up to 3 diameter	$1.24	$1.55
4, 5, and 6	1.88	2.33
8, 10, and 12	2.73	3.41
14, 16, and 18	3.41	3.91
20 and 24	4.08	5.12
26, 28, and 30	4.99	6.25

On pipe heavier than Schedule 40 erection costs will be in proportion to the increased weight. As an example 3-in. double extra heavy pipe will be calculated as 6-in. Schedule 40, short pieces flanged will be calculated on a minimum length of 5 ft. Flanged valves, elbow bends, or other special fitting will be calculated as 5 ft. of piping. Welding end valves will be calculated on the basis of 5 ft. of piping plus two welds.

The above prices may be considered to include installation of what is termed simple pipe hangers including pipe rollers and brackets. Any special hangers or supports will be calculated as an addition. These costs also include an allowance

Louis J. Mrachek, Project Engineer in Charge of Construction, The Mead Corp., Kingsport, Tenn.

clarify wastes at least cost...

the Cyclator®

meets disposal requirements best...

1 Because the Cyclator combines recirculation for more complete clarification and faster settling with mechanical thickening for maximum sludge compaction... you gain greatest B.O.D., oil and suspended solids reduction at considerably higher flow rates than in "old style" disposal plants.

2 Because the Cyclator increases purification rates and eliminates the need for large chemical mixing, coagulating and settling basins, you save space... save on first costs.

3 Case histories of Cyclator operation dramatically

(continue to next page)

INFILCO
since 1894

(continued from preceding page)

illustrate the vital point that the Cyclator will clarify wastes to your local requirements at least cost. Write for Bulletin 850A — containing data and case histories which show how the Cyclator exceeds expectations for processors everywhere — North America, South America, Europe.

INFILCO INC. ★ *Tucson, Arizona*

Here's how the Cyclator EXCEEDS waste disposal requirements

- ★ Space-savings up to 80% in comparison to "old-style" treatment plants.
- ★ By-product recovery and water re-use pay for Cyclator operation in many cases.
- ★ Removes suspended and colloidal solids, oils and toxic compounds rapidly and efficiently.
- ★ Throughput is extremely high because chemical feeding, recirculation and mechanical thickening are perfectly balanced in a single basin.
- ★ Reduces chemical costs because most efficient mixing is attained with recirculation.
- ★ Effluent purified to the degree required to meet pollution control regulations.

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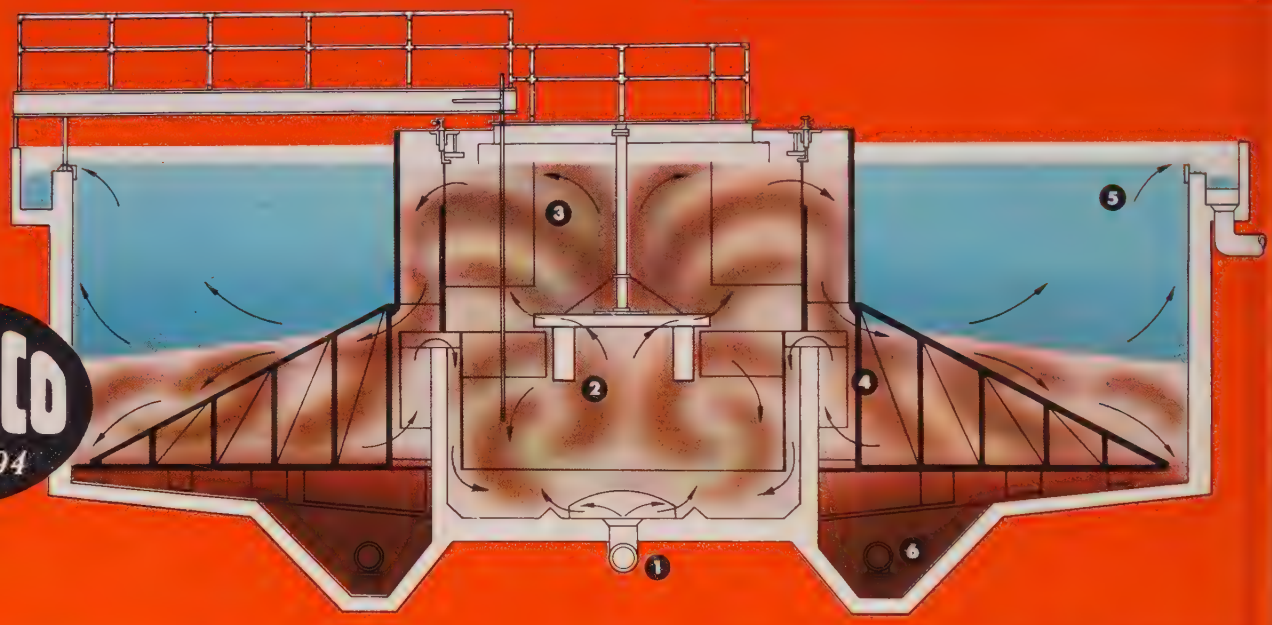


"EXPLAIN-MORE" DIAGRAM

1. Inlet
2. Mixing & Coagulating Zone
3. Circulating Zone
4. Recycling Zone
5. Clarified Liquid
6. Sludge Sump

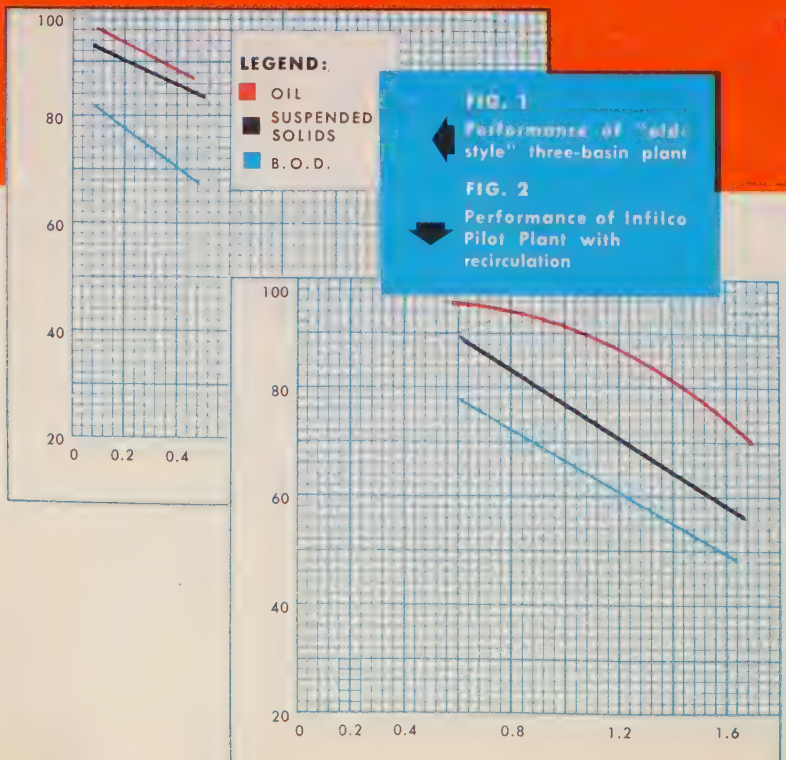


FIG. 1 Performance of "old-style" three-basin plant

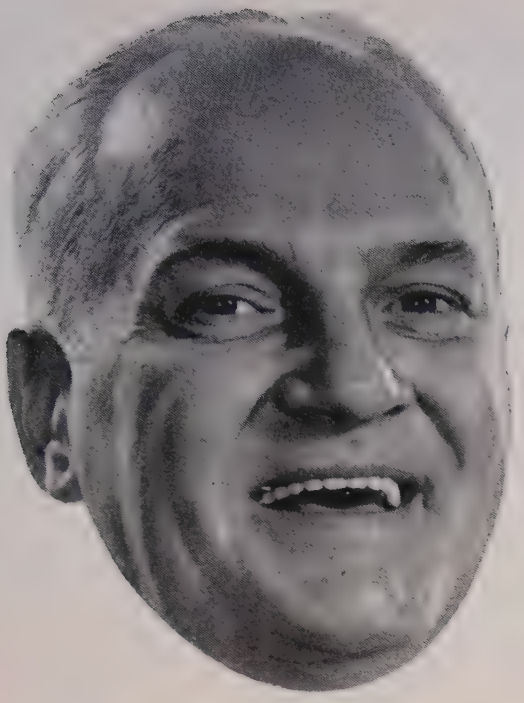
FIG. 2 Performance of Infilco Pilot Plant with recirculation

TAKE A LOOK AT PROCESS SAVINGS—

Here's a recent pilot plant study. An Infilco pilot plant was installed in parallel with a treatment plant with separate mixing, flocculating and sedimentation basins.

Both plants treated oil-bearing wastes. Alum and activated silica were used as the coagulants. Figure 1 shows that the three-basin plant operated at a rise rate of only 0.2 gpm per square foot for about 95% oil removal. Slightly higher removal was gained with the Infilco plant and at a rise rate of 0.6 gpm.

The result: two 100-foot diameter Cyclators were installed by a large Eastern refinery to treat waste at 3700 gpm. Process savings like this are typical of Cyclator installations. When you need facts for waste disposal at least cost, ask for Infilco's specialized experience . . . there's no obligation for preliminary planning.



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No matter what your present sizing practice may be, it will pay you well to have a representative of the Glidden Technical Service demonstrate all the advantages you can gain from using Prosize in your mill. After changing from conventional rosin size to Prosize, users have reported that . . .

- Prosize Process is 200 to 300% more efficient.
- Prosize Process produces a better, more stable size which gives paper uniform resistance to liquids of various types, such as ink, water, meat juices, etc.
- Prosize Process permits duplication of results from run to run on grades never before made because of sizing difficulties.
- Prosize Process minimizes seasonal variations—is highly effective on stocks heated by long beating or hard jordaning.
- Prosize Process permits sizing at a higher or more neutral pH.
- Prosize Process requires from 35 to 65% less rosin size and from 15 to 30% less alum, making it generally *less expensive* to use.

Prominent mills with a combined production of thousands of tons of paper a day have proved this patented Glidden Prosize Process, utilizing Glidden Alpha* Protein in combination with rosin size and boric acid, to be a superior means of sizing.

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Full volume control.
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Requires minimum maintenance.
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BRAMMER *recording consistency control*

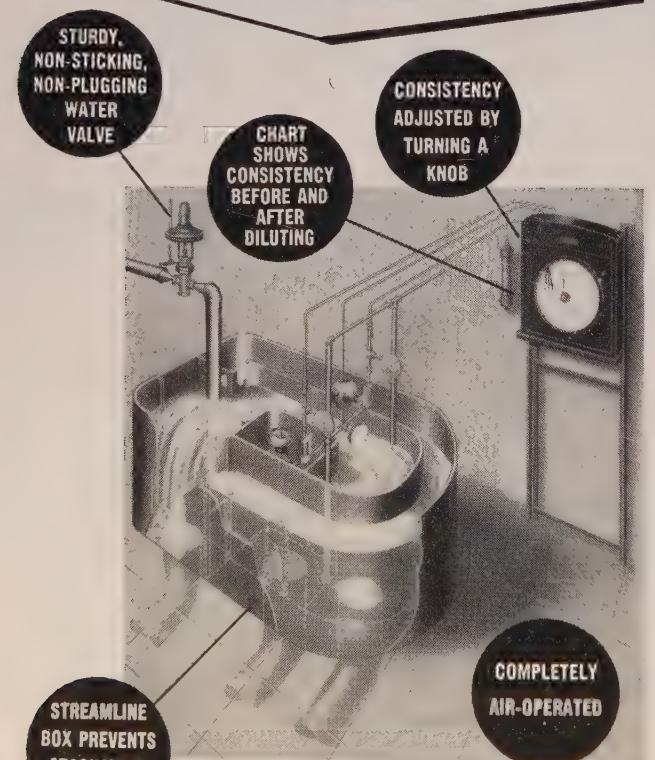
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CHART SHOWS CONSISTENCY BEFORE AND AFTER DILUTING
CONSISTENCY ADJUSTED BY TURNING A KNOB
STREAMLINE BOX PREVENTS STAGNATION OF STOCK
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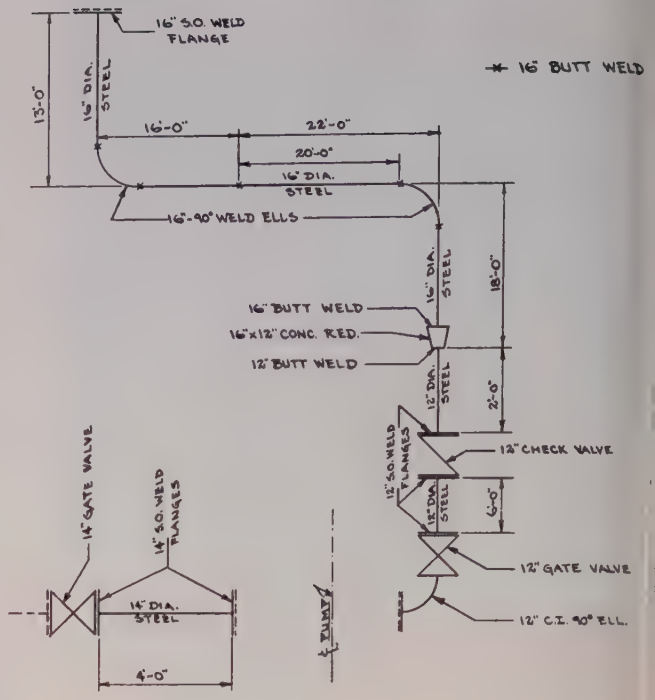


Fig. 1

for handling of material from a point of storage on the site to the installation.

Let us take for example a typical pipe installation shown by Fig. 1:

Summarizing the "take-off," the labor costs would be figured as follows:

Fabrication:	
2—14-in. S.O. flange weld at $47.64	$ 95.28
3—12-in. S.O. flange weld at 40.84	122.52
1—12-in. Butt weld at 33.39	33.39
6—16-in. Butt weld at 45.50	273.00
1—16-in. S.O. flange weld at 54.45	54.45
	$578.64

Erection:	
14-in.—4 ft. plus 1 fitting at 5 ft. = 9 ft. at $3.41	$ 30.69
12-in.—8 ft. plus 3 fitting at 5 ft. = 23 ft. at 2.73	62.79
16-in.—69 ft. plus 0 fitting at 5 ft. = 69 ft. at 3.91	269.79
	$ 363.27

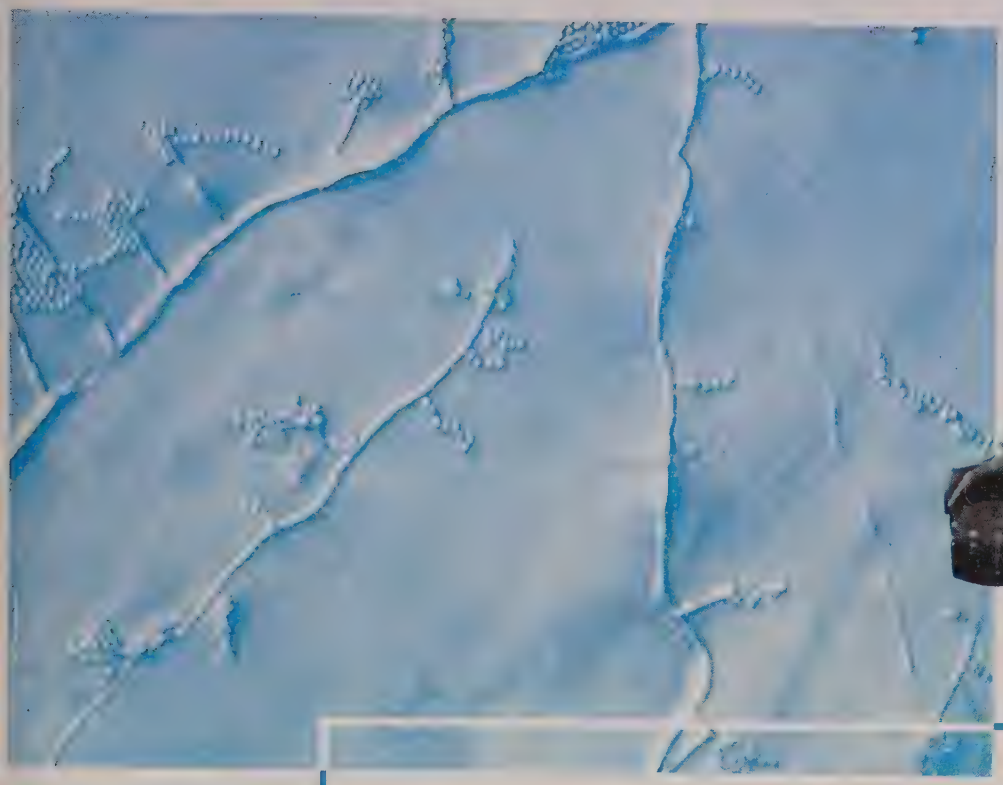
Therefore the total labor costs would be:

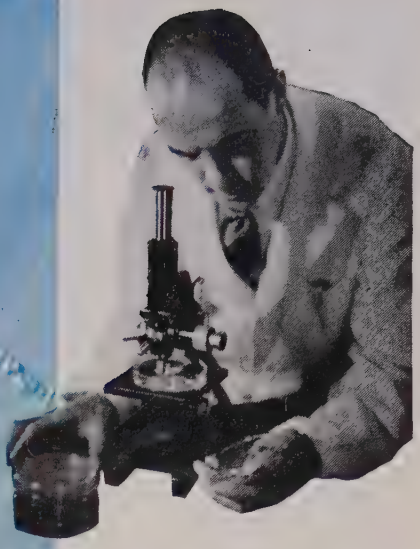
Fabrication	$578.64
Erection	363.27
	$941.91

If the pipe fitters are being paid $2.42 per hour instead of $2.50 per hour, which is used as our base, the cost of fabrication and erection cost would be proportional; i.e., $2.42/$2.50 × $941.91 = $911.77.

It must be realized that in an effort to develop a relatively simple procedure of estimating, certain factors are accepted as standard. In following this practice it is obvious that where an unusual application is required, such as special hangers or structural members, brackets, guides, or anchors, allowances for such work must be made and added to the cost estimate. Furthermore, if material handling problems and/or working conditions are difficult, if special work schedules or premium time are anticipated, such factors, certain to reflect cost increases, must be acknowledged.

In general, we recognize the shortcomings of our system and do not offer it as a substitute for detailed piping cost estimates. The intention and purpose of our short cut is with applied "horse sense," to afford the plant engineer a quick method of establishing construction budgets and checking construction bids.





Left — Microphoto of Monilia (White), one of the slime-forming micro-organisms frequently found in paper mills and controlled by the Nalco System. Photos in Nalco Laboratories.

FORMULA FOR SUCCESSFUL SLIME CONTROL

SLIME control, like paper making itself, requires constant and careful attention to details. Here is a formula for successful slime control which will cut to a minimum, spots and specks, breaks, cleaning, and other costly problems due to slime:

- Identify slime-forming organisms to be controlled.
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- Determine the best types of treatment to be used.
  A NALCO SERVICE
- Locate, by detailed survey, the proper points of application.
  A NALCO SERVICE
- Provide consistent supervision to check application and effectiveness of treatment.
  A NALCO SERVICE
- Maintenance of high standards of sanitation throughout the mill. (Even the best of treating and scientific control can be seriously hampered by unsanitary conditions.)

Nalco Field Representatives and the modern, scientific facilities of the Nalco Laboratories are at your service to put this formula for successful slime control into practical operation in your mill. Write for details today.

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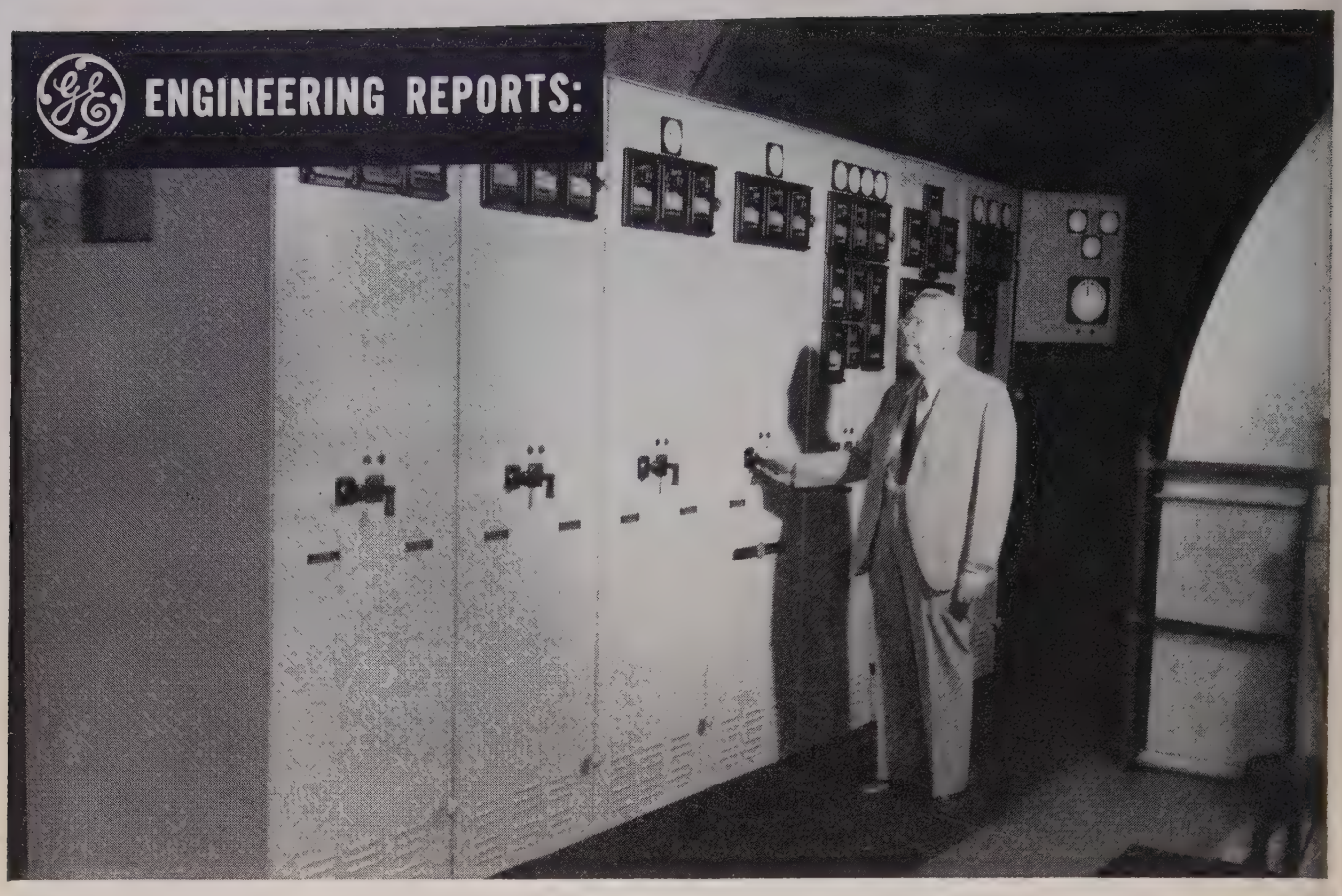
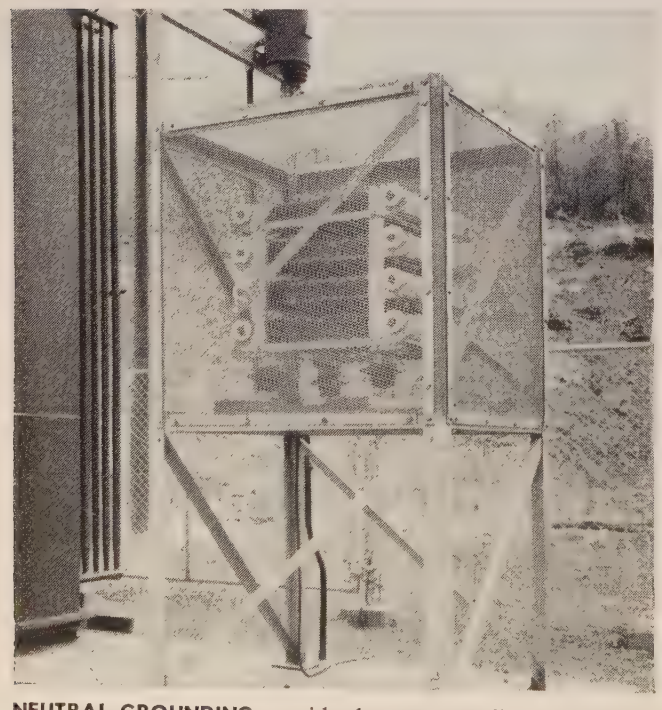


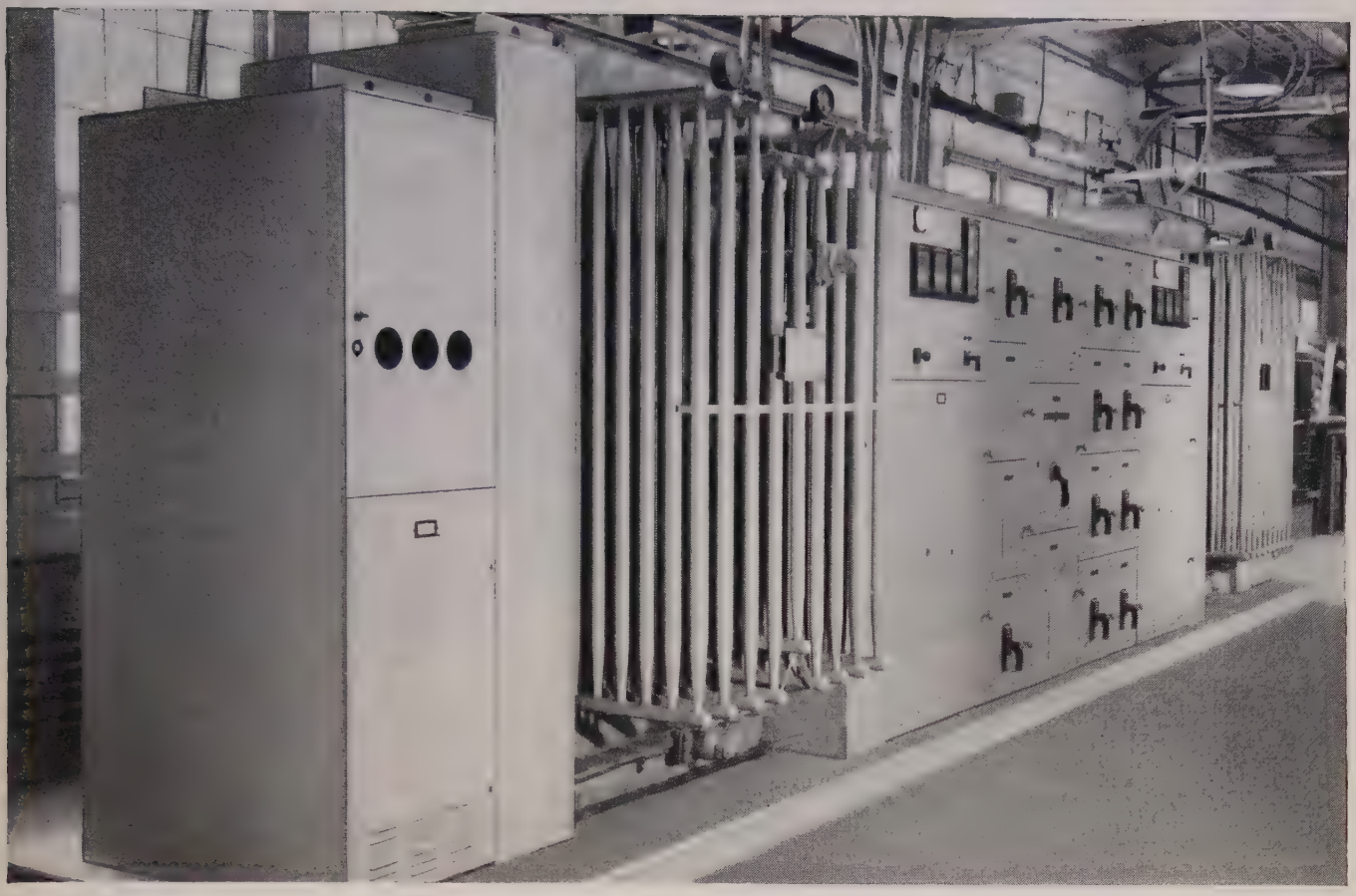
AMPLE IC. G-E metal-clad switchgear at Gardner has ample interrupting capacity for both present load and future expansion. Alfred Clegg, power house chief, likes the operating convenience of centralized control for main power circuits.

Modern power distribution system



NEUTRAL GROUNDING provides better over-all system operation. This resistor in the neutral of the 4160-volt system limits ground-fault current minimizing damage to equipment.

G-E APPLICATION ENGINEERS, with tools like this portable analyzer, can study your entire power system quickly—and recommend the proper system for your present and future load.



PROTECTS PRODUCTION. This 3000-kva G-E double-ended unit substation is one of two that insure against complete shutdown in stock preparation areas by providing an alternate 480-volt power source via secondary-selective arrangement.

protects production at Gardner

Secondary selective arrangement also adds flexibility for future expansion, more safety for personnel—neutral grounding minimizes equipment damage due to ground faults

Recently the Gardner Board and Carton Company of Lockland, Ohio, realizing that modern paper-making machinery does a continuous, high-tonnage job only when supplied continuously with adequate electric power, modernized its plant's power distribution system. Completely engineered and equipped by General Electric on an economical step-by-step basis, the new system includes such modern engineering advances as these:

"Building-block" load-center unit substations that reduce power distribution costs and make future expansion easier—factory-assembled metal-clad switchgear that cuts installation cost and protects equipment and feeders—high-voltage power distribution for full voltage at the motors and higher operating efficiency—a secondary selective arrangement that safely provides a dual power-supply route for greater reliability and continuity of production—and neutral grounding of both the 4160- and 480-volt systems for greater safety to personnel and lower over-all downtime for outages.

Let your local G-E apparatus sales representative tell you how G-E engineers can analyze your entire power system quickly, and help you select the proper equipment to fit your plant's needs.

Meanwhile, write for bulletin GEA-5521, "Power System Equipment for Pulp and Paper Mills" and technical article GET-1181C, "Neutral Grounding of Industrial Power Systems." Section 655-12, General Electric Company, Schenectady 5, N. Y.

Engineered Electrical Systems for Paper Mills

GENERAL ELECTRIC

Alkaline Pulping Progress in 1951*

SIDNEY D. WELLS

DURING 1951 progress in pulping by alkaline processes has continued its rapid advance in technology and extent. The *Library Notes* of The Institute of Paper Chemistry presents monthly abstracts of articles shortly after they appear in the technical literature. *Chemical Abstracts* furnishes a similar treatment of a broader field which includes the field of pulp and paper technology. "Bibliography of Pulp and Paper Manufacture, 1951," and "United States Patents 1950–51," compiled by Clarence J. West, continues the compilation of material of interest to the industry. These publications are all available to workers in the field.

Paper is becoming increasingly important in daily life and the national economy and the rate of growth of consumption exceeds the growth in population or other indices usually associated with statistical analysis. The annual United States production in 1950 was 11.5 times that of 1899. Stevenson (*1–3*) and Neubrech (*4*) presented economic reviews of pulp, paper, and board. The Food and Agriculture Organization of the United Nations presented world figures (*5*), and Dobrow (*6*) announced another paper production record. Abele (*7*) reported on the industry in the United States. Every (*8*) reviewed the unbleached kraft paper industry. *Chemical Engineering* (*9*) reported new plants and facilities under way. Clauson (*10*) reviewed the market pulp field; Fowler (*11*) asserted that pulp and paper are keeping pace with Canada's industrial growth. Burke (*12*) reported for the sulphite manufacturers. Bettendorf and Helme gave wood pulp and pulpwood statistics (*13*) and paperboard figures (*14*), and Newburg, Bettendorf, and Helme (*15*) gave paperboard mill industry statistics. The *Paper Mill News* (*16*) presented a general review of 1950–1951.

Beracha (*17*) reflected the concern in France over obtaining sufficient raw materials.

Josephson (*18*) dwells on the possibilities for expansion of the pulp and paper industry by going to Alaska, as was advocated by Henry E. Surface in 1917, and by Heintzleman (*18a*) in 1926. The Organization for European Economic Cooperation (*19*) reported on the growth of the kraft paper industry in the southern states. Wolfe (*20*) enlarged on the same subject, as did Albert (*21*). James and Duerr (*22*) commented on the income in the South from timber products. Turcotte (*23*) presented the pulp situation. Hill (*24*) considered the extent of Canada's industry for producing market pulp, and *Chemical Week* (*25*) discussed the entrance of hardwood pulps into the market, especially for dissolving pulp, and Bullock (*26*) reported the shifting of imports to specialties.

EXPANSION IN THE UNITED STATES

Tremendous expansion has occurred or is in the course of construction. The *Paper Mill News* (*27*) estimated it to be of the order of $500,000,000. The Organization for European Economic Cooperation (*28*) reported on the industry in the United States as seen by visitors sent over as part of the program. The American Paper and Pulp Association (*29*) made a survey of contemplated capacity, and *Pulp and Paper* (*30*), and Perry (*31*) covered similar ground. Addresses by Everest (*32*) and Stevenson (*33*) dwelt on the industry's position for meeting the problem of war. Escarfail (*34*) considered the problem from the point of view of a French writer.

Much modernization with new and specialized products is occurring in New England (*35*). S. D. Warren is reported as being active (*36*). Perez (*37*) reported on the pulpwood supply under present conditions in New York State. *Southern Pulp and Paper Manufacturer* reported on the conversion of the West Virginia Pulp and Paper Co.'s Maryland mills to the sulphate process (*38*). Pulpwood handling, semichemical pulping, and washing and bleaching facilities are also being installed at Covington, Va. (*39, 40*).

Stevenson (*41*) announced that 52% of the pulp-making capacity and 30% of the papermaking capacity of the United States are now in the South. Tinker (*42*) emphasized the importance of the South's pulp and paper production. The *Paper Mill News* (*43*) announced the completion of the modernization program of the original kraft paper mill in the South. *Pulp and Paper* (*44*) also announced its 5-year improvement program. Porter (*45*) reported the expansion of The Chesapeake Corp.'s mill to 500 tons daily capacity. *Pulp and Paper* (*46*) described the installation of a 270-in. fourdrinier at the Hummel-Ross mill. *Southern Pulp and Paper Manufacturer* (*47*) announced the major expansion at Camp Manufacturing Co. *Pulp and Paper* (*48, 49*) also described the mechanization and integration. Modernization of the West Virginia mills and the improvements at Charleston were listed by McGinn (*50*) and the *Paper Mill News* (*51*). Brunswick Pulp and Paper Co. has increased production to 400 tons of bleached kraft daily as a result of a $6,000,000 expansion (*52, 53*).

Sutlive (*54*) described the Union Bag & Paper Corp. as the largest kraft paper mill in the world. Calder (*55*) made the announcement early in 1951, and Fox (*56*) told the story; *Paper Mill News* (*57*) announced more modernization, and *Southern Pulp and Paper Manufacturer* (*58*) announced a new mill under construction at Rome, Ga., on the Coosa River. Also in Port Wentworth is the new mill of the Southern Paperboard Corp. now in active production (*59*). The St. Regis Paper Co. was reported to be making a $30,000,000 expansion in northern Fla. (*60, 61*). Pulp and paper production was hailed by Wright (*62*) as Florida's new king. *Southern Pulp and Paper Manufacturer* (*63*) described the newly expanded mill of the Hudson Pulp and Paper Corp.; *Paper Mill News* (*64*) and *Paper Trade Journal* (*65*) also described the plant. Recently, the acquisition of the Brooks Scanlon timber stands by the Buckeye Cellulose Corp. is the basis for a large new mill for dissolving pulp in northwestern Florida (*66*).

The International Paper Co. announced a $75,000,000 modernization program, including the doubling of its capacity for dissolving pulp from hardwoods at Natchez, Miss., to a daily capacity of 600 tons (*67*). *Pulp and Paper* (*68, 69*) in a series of articles described how Southern Kraft of the International Paper Co. has organized its enormous wood procurement operations. *Crane Valve World* (*70*) presented an illustrated article of the completed Coosa River mill. Edge (*71*) described Ruberoid's new roofing mill at Mobile. McGinn (*72*) described the expansion at the Crossett paper mills.

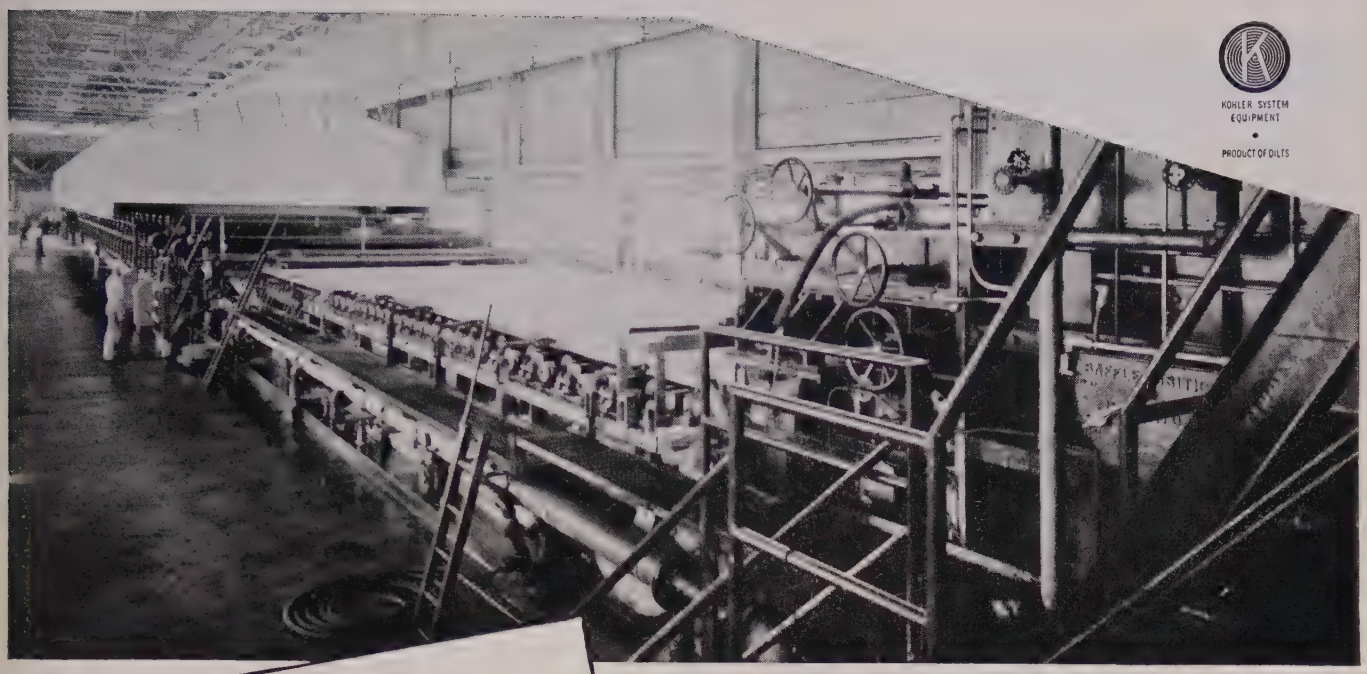
The *Paper Mill News* (*73*) described the modernization program at Kingsport, Tenn. McGinn (*74*) and *Pulp and Paper* (*75*) described the expansion and new fourdrinier at Lee, Mich.

McGinn (*76*) described the expansion at the Thilmany Pulp and Paper Co. The *Paper Trade Journal* (*77*) presented 50 years of progress at the Northern paper mills and Pratt (*78*) the improvements at the Hoberg paper mills. *Paper Mill News* (*79*) presented the expansion program at the Nekoosa-Edwards Paper Co., and *Pulp and Paper* (*80*) the effective engineering at the Biron plant of the Consolidated Water Power and Paper Co.

Paper Trade Journal (*81*) and *Paper Mill News* (*82*) presented the $3,500,000 expansion of the Rhinelander Paper Co. *Paper Industry* (*83*) described the improvement program of the Flambeau mill. *Paper Trade Journal* (*84*), *Paper Industry* (*85*), Williams (*86*), and *Paper Mill News* (*87*) all de-

SIDNEY D. WELLS, Research Associate, The Institute of Paper Chemistry, Appleton, Wis.

* Sponsored by the Alkaline Pulping Committee of the Technical Association of the Pulp and Paper Industry, Robert R. Fuller, Chairman. Southern Pulp and Paper Manufacturer finances the preparation of this report annually for TAPPI as a service to the pulp, paper, and paperboard manufacturers.



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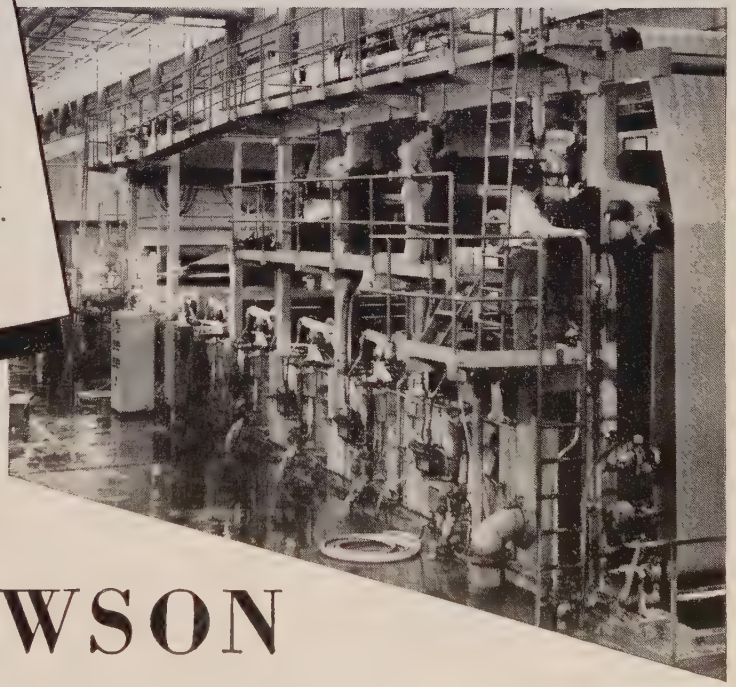

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scribed the Minnesota and Ontario $17,000,000 expansion program now under way.

Pulp and Paper (*88*) reported on a visit to Colorado studying the Columbine Development. Waters and Wheeler (*89*) described the operation of the Potlatch Forests new mill at Lewiston, Idaho. *Fibre Containers* (*90*), *Paper Trade Journal* (*91*), *Pulp and Paper* (*92*), *Paper Mill News* (*93*), and Porter (*94*) of the *Paper Industry* also presented articles on the same mill. *Paper Mill News* (*95*) described the Crown Zellerbach modernization program, and *Paper Trade Journal* (*96*), the Camas story. *Pulp and Paper* (*97*) disclosed the new wood room and paper machine of the Longview Fibre Co. The cooperative association of the Puget Sound Pulp and Timber Co. and the American Viscose Corp. promised a 300-ton dissolving pulp plant at Ketchikan estimated to cost $40,000,000, which will bring in Alaska as an important source of cellulose fiber (*98*).

O'Neil (*99*) pointed out the use of unused species which will improve the position of New York State in the paper industry. Chesley (*100*) reported on repulping runs on kraft rejects, and Little (*101*) pointed to the native species of New Mexico and Arizona as a source of pulpwood supply.

EXPANSION IN OTHER COUNTRIES

Clermont and Schwartz (*102*) reported the chemical composition of Canadian woods, including balsam fir, white spruce, black spruce, jack pine, white birch, eastern hemlock, white pine, and quaking aspen. Fitzgerald (*103*) considered the maturity of paper communities in Newfoundland. The Bowater growth and expansion in Canada have been described (*104*), as well as Bathurst's modernization to make corrugating medium (*105, 106*). Expansion at the Cornwall mill of Howard Smith, the installation of a new machine (*107, 108*), and activity at the Thorold mill of the Provincial Paper Ltd. (*109, 110*) and Kimberly-Clark's developments at Kapuskasing were described (*111, 112*). Powell River's developments were reported at the halfway mark (*113*). Celanese plans for the Arrow Lakes district of British Columbia were announced (*114*). Installations at Harmac have been described (*115–117*). Columbia Cellulose is operating the first sustained yield operation in British Columbia (*118, 119*). The pulp and paper industry in Canada accounts for the principal volume of manufacture and export looms large in the economy of the country (*120, 121*). Significant increase in per capita consumption has occurred in America (*122*). Cycles in per capita consumption are observed with paperboard at present taking the lead (*123*). Serious declines occurred in 1948–49 (*124*). The industry is gaining in favor as a sound object for investment (*124a, 125*). The pulp situation from the standpoint of dissolving pulp was touched upon (*126, 127*); Kotte (*128*) reviewed the situation in North America, and the problem of France was discussed (*129*). A Finnish kraft board mill has started operation (*130*). Data on paper and board production were given, as well as the official board mill directory (*131–133*).

The annual review of alkaline pulping progress for 1950 appeared in Oct., 1951 (*134*). The dominant position of the United States in the pulping field was indicated in *Unasylva* (*135*). Ritchie (*136*) considered the United States' wood pulp supply and Perry (*137*) the effect of the current expansion. Every (*138*) commented on new fields opening for kraft paper. McGinn (*139*) showed that improvements in pulping increase the supply by yielding more pulp. Maematsu (*140*) reported on the use of paper mulberry (kozo) in Japan, and Cruikshank (*141*) on the cellulosic raw material situation. Aggarwala (*142*) described the U. S. paper industry from the standpoint of India. Ronkanen (*143*) stated that, on the average, four years elapse between cutting and pulping in the mill. Varis (*144*) explained why pulpwood is cut in longer lengths in eastern Finland. Pöyhönen (*145*) pointed out that shorter lengths are preferred for mills in western Finland and Sihtola (*146*) discussed the subject in general. Dunwody (*147*) disclosed an improved chipping process.

NEWSPRINT

The urgent demand for newsprint has directed attention to the world supply in a way that would not occur in normal times. The Canadian mills have modernized and expanded without increasing the number of new units to any marked extent. Fowler (*148*) discussed the problems and responsibilities of the industry. Tipka (*149–151*) discussed the volume manufactured. The United States Congress made an exhaustive investigation (*152*). Crawford (*153*) called attention to the potentiality of Alaska. Campredon (*154*) showed how hardwood utilization can contribute to supply the needs of France. Bhargava and Singh (*155–157*) commented on how India can become more self-sufficient. The Technical Section of the Canadian Pulp and Paper Section (*158*) and Sigal (*159*) reported on calender stack operation and the waterproofing of newsprint, respectively.

WOOD PROCUREMENT

With the increase in manufacturing facilities and their improvement, the improvement of wood procurement methods has proceeded. Chemistry assumes increasing importance (*160–164*). Hydraulic barking has also advanced (*165–174*), bringing with it better integration of the saw mill with the pulp mill, and the utilization of slabs and edgings. West (*175*) and *Pulp and Paper* (*176*) showed how 8-ft. pulpwood is being barked and chipped. Pauley and McCanna (*177, 178*), Hogan (*179*), Leffler (*180*), Piispanen (*181*), Laulainen (*182*), Åström (*183*), and Alfsen (*184*) disclosed various barking devices. Also the Canadian Department of Resources and Development (*185*), Martin and Brown (*186*), Harrison (*187*), Farris (*188*), Paper Mill Equipment Ltd. (*189*), and the *Lake States Timber Digest* (*190*) reported on activity in this field. Greneker (*191*) discussed the significance of replacing the cracker barrel with packaging for the ultimate customer for display and self service for merchandising. Isenberg (*192*) published the second edition of his "Pulpwoods of the United States and Canada." Fries (*193*) published "Empire in Pine," and Greeley (*194*) his "Forests and Men." Malsberger (*195*) issued the Forester-General Manager conservation report. Bond (*196*) published "Cutting for Profit in Southern Pine Woodlands." Porter (*197*) exhorted more trees in the South. Watzek (*198*) described Crossett's forest policies. Herr (*199*) presented a forestry program for selling private forestry to the workers and the public. Cooper (*200*) discussed the integration of forest-using industries. *Pulp and Paper* (*201*) described the Penobscot Experimental Forest and what it is doing in Maine.

Kingston (*202*) pointed out the need for training fire fighting crews. R.C.A. Victor Co. (*203*) described forestry communication systems. *Pulp and Paper Magazine of Canada* (*204*) showed how amphibious aircraft solve many problems. Hanchet and Drummond (*205*) and *Pulp and Paper Magazine of Canada* (*206*) suggested the use of helicopters for combating fires.

Pulp and Paper (*207*) discussed forest management in Virginia. Stewart (*208*) pointed out how engineering is used in forest protection. Armstrong (*209*) showed how wood waste can be used for pulping, and Hooker (*210*), the American Grip Trip bundling chain in pulpwood logging. Damtoft (*211*) discussed fifty years of industrial forestry progress and Huber (*212*) described sustained yield management as practiced in Switzerland. Cowan (*213*) described the training of forest personnel in simple conservation measures, and Johnson (*214*) considered a new era in forest management. Robertson (*214a*) discussed pulpwood in the backyard. McColl (*215, 216*) described the Bonnard prehauling unit and developments in mechanical logging. Carson (*217*) described the construction and layout of Marathon's camps, Hamilton (*218*)

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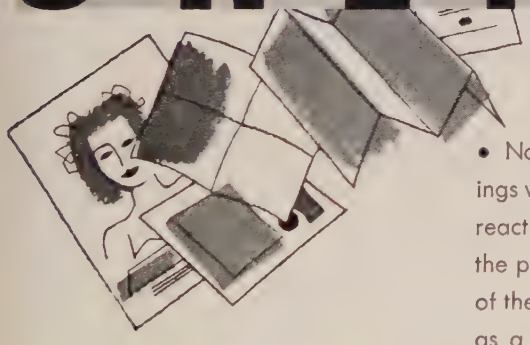

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the use of spar trees, Harkness (*219*) the forestry aspects of mechanical logging, Lunam (*220*) the mechanics of slashing, Olson (*221*) the latest mechanical developments, and Husak (*222*) high lead yarding.

Berg and Anker-Rasch (*223*) and Wibstad (*224*) discussed transportation problems in the forest industries and McIntosh (*225*) the floating properties of pulpwood logs. Johnson (*226*) reported the experience of the Mersey Paper Co. with partial and selective cutting and Carlson (*227*) mechanized logging at LongLac. Withenshaw (*228*) described the use of the Drott loading and truck hauling of 16-ft. pulpwood at Abitibi, the Thilmany Pulp and Paper Co. (*229*) their new conveyor system, the Stephen-Adamson Manufacturing Co. (*230*) their conveyor elevator system for wood chips, Zabriskie (*231*) a conveyor system for reducing costs, and *Paper Mill News* (*232*) modern wood handling on the West Coast. *Pulp and Paper Magazine of Canada* (*233*) considered the use of publications and visual aids for training logging personnel, Busch (*234*) the use of sulkies, Larson (*235*) the portable logging tower, Tateishi (*236*) high lead yarding of tree length pulpwood, and *Pulp and Paper* (*237*) log sorting. Goodfellow (*238*) discussed the use of pulpwood chips as a by-product of sawmill operation, Evans (*239*) a report of a field meeting on mechanical hauling and cable yarding at LongLac and Marathon, Warburton (*240*) the inventory by air of log block piles, and Seymour (*241*) the method of making an inventory of straw-piled wood.

Moir (*242*) discussed the pulpwood situation in the Pacific Northwest, Farley (*243*) wood handling and servicing at Camas, *Pulp and Paper* (*244*) the woodmill addition at Camas, and Levón (*245*) forestry in Argentina. Ottersland (*246*) disclosed a disk chipper with horizontally inclined rotary axes. McLeod (*247*) discussed pavements for logging roads, the Canadian Pulp and Paper Association (*248*) the training of woods supervisory personnel, Nekoosa-Edwards (*249*) a pioneer new tree planter, Johnson (*250*) queries on how are the timberlands doing, and Klem (*251*) reported on floating and sawing of barked and unbarked wood. Murdock (*252*) discussed the changing Japanese pulpwood situation, Bassett (*253*) the sale of crown timber in British Columbia, the American Paper and Pulp Association (*254*) new capacity planned for the paper and board industry, and Nishida and Watabe (*255*) the effect of seasoning on the sulphite digestion of *Larix kaempferi*.

Wegelius commented (*256*) on the mill storage of pulpwood, Pepler (*257*) on the use of zoning to reduce fire hazards, the Canada Paper Co. (*258*) on the value of hardwood removal on forest management, Skiff (*259*) on public and private forestry, Foster and Foster (*260*) on the decay of Western hemlock on the Queen Charlotte Islands, B. C., Maartmann (*261*) on utilization of wood of small dimensions, Magill (*262*) on developments in trailer design, Roche (*263*) disclosed a chip distributor, and the North Star Timber (*264*) a hydraulic loader and a dray-mounted arch.

Paper Industry (*265*) discussed the procurement of pulpwood for Wisconsin mills, especially rafting across Lake Superior. Reynolds (*266*) presented pulpwood production costs in Arkansas, Holt (*267*) discussed cutting methods in logging in eastern Canada, and Carlson (*268*), the handling and movement of pulpwood at LongLac. Collier (*269*) pointed to progress in skidding by wire in Canada, Guernsey (*270*) discussed wood waste utilization in the Douglas-fir region, and Hurter (*271*) disclossed an improved chip storage bin. Shaughnessy (*272*) discussed the use of radio communications, and Ware (*273*) commented on the blind spots of bankers in forestry development.

The Union des Importateurs de Pâtes à Papier (*274*) pointed out the importance of the United States and Canada in the paper economy of the world. *Pulp and Paper* (*275*) gave a world-wide review. Catleen (*276*) surveyed world exports. Roe (*277*) pointed out the sharp reduction of British imports from Canada. The Union des Importateurs de Pâtes à Papier (*278*) reviewed the French paper industry, Voorn (*279*) described the presently operating paper mills in Holland. Kotte (*280*) reported on a rapid trip to the new and old paper mills in France. *Paper and Timber* (*281*) described the Tervakoski mill in Finland founded in 1818 and still operating a machine built by combining two Donkin and Bermoudsey machines delivered in 1850 and 1860. *Svensk Papperstidn.* (*282*) wrote up the Jubilee of Nyboholms Aktiebolag. *Pulp and Paper* (*283*) reported on Atenquique (Mexico) five years after commencing operation and also (*284*) reported on the $20,000,000 kraft expansions in New Zealand based upon pine. Gepp (*285*) described the pulp, paper, and board industry in Australia. *Pulp and Paper Magazine of Canada* (*286*) described the new board mill being built in Tasmania.

The U. K. Commercial Counsellor (*287*) considered the Swiss paper market favorable for British products. Westberg (*288*) discussed the educational program of the Swedish cellulose group. Fischer (*289*) reviewed and forecasted the German pulp and paper industry. The Norwegian Paper Makers Association (*290*) surveyed its membership. Porphyre (*291*) outlined the possibility of raw material supplies from the mother country and the French Union. Venkajee (*292*) dwelt on the development of the paper industry in Assam. The Titaghur Paper Mills Co. (*293*) announced an addition to their group. Tribeni Tissues started up their new mill in West Bengal (*294*). *Indian Pulp and Paper* (*295*) described the Pudukotah Paper Mills, Ltd. Alley (*296*) discussed the Japanese paper industry, and *Southern Pulp and Paper Manufacturer* (*297*) announced a new plant for Sonoco in Mexico.

Bowater Papers (*298*) presented the "Fourdrinier Saga," showing the early development of the fourdrinier paper machine. McDermott (*299*) discussed problems relative to the high-speed paper machine. The Deculator for deaerating pulp suspensions was described (*300*) and DeCew (*301*) disclosed a method for the deaeration of papermaking fibers. Bradbury and McCullough (*302*) discussed the characteristics of sheets made of groundwood pine and pine kraft mixtures. Kane (*303*) discussed the beating, tensile strength, specific surface, and optically bonded area of pulp.

SILVICULTURE

Johnsson (*304*) reported on progeny tests on birch. Jensen (*305–307*) reported on birch as a raw material for pulp and its technical and chemical aspects. Pourtet (*308*) discussed poplar and its place in the world. Andersson and Strand (*309*) presented data on two comparative experiments with aspen. Campredon (*310*) discussed poplars in papermaking, Hilf (*312*), the culture of poplars, and Klauditz (*313*), the mechanical properties and chemical composition of trunk wood of two poplar hybrids. *Fortune* (*314*) discussed uniform paper from mixed forests, Chittenden, Coomber, and Morton (*315*) the use of brachystegia wood from Tanganyika, Wise, Rittenhouse, and Garcia (*316*) the chemical composition of eight tropical woods, and Chittenden, Coomber, and Corney (*317*) *Eucalyptus saligna* from South Africa. *Revue papiers et cartons* (*318*) queried the adequacy of the mill at Bimbesso for relieving the French paper shortage. Levón (*319*) discussed the forestry of Brazil. Sawada (*320*) reported on the neutral sulphite semichemical pulping of *Cinnamomum camphora*. Hess (*321*) discussed pulpwood from tropical forests. Navarre and others (*322*) the possibilities of short-fibered pulps, and Chittenden and Coomber (*323*) the suitability of brachystegia, isoberlinia, and other hardwoods of northern Rhodesia for the manufacture of fiberboards. *Chemical Week* (*324*) and Rothrock and Nolan (*325*) discussed the alkaline pulping of scrub oak. Jayme (*326*) discussed the significance of the tension wood content of poplar. Villars (*327*) reported on the manufacture and utilization of hardwood pulp. Levón (*328*) discussed the forests of Argentina. Lewis (*329*) reviewed redwood as a potential source of pulp,

Riegel DOUBLES in economy

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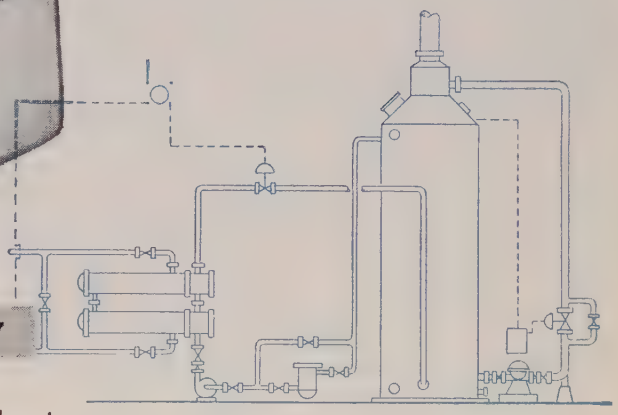


1. DIGESTER BLOW STEAM HEAT RECOVERY

For heating clean pulp wash water, Riegel chose the low-cost, high-heat-recovering liquid-to-liquid system with scale-resistant, non-corroding tubes. The system is capable of heating 755 gpm of clean water from 75 to 160 F. A feature of this system is the non-plugging condenser which allows clear blow-through without back pressure.

2. TURPENTINE RECOVERY

For the added revenue in recovering 2 to 4 gallons of of turpentine from each ton of pulp and the economy of fuel saved through heat recovery in the condenser, they chose an FW system consisting of a cyclone separator, condenser and gravity separator.

This new installation by Riegel-Carolina Corporation at Acme, N. C. confirms once again not only the sound economics of turpentine and digester heat recovery but also the continued acceptance of Foster Wheeler equipment by pulp mills.

Perhaps our experience in heat and turpentine recovery can be of assistance to you. If so information describing these Foster Wheeler systems will gladly be sent on request.

FOSTER WHEELER CORPORATION • 165 BROADWAY, NEW YORK 6, N. Y.

FOSTER WHEELER

and *Norsk Skogindustri* (*330*) surveyed the Australian forest industry.

SEMICHEMICAL PULPING, BUILDING, AND HARDBOARDS

Wells (*331*) presented the history and development of semichemical pulping. The Lake States Section of the Technical Association of the Pulp and Paper Industry held a panel discussion on hardwood utilization (*332*). *Chemical Engineering* (*333*) proposed more pulp and less pollution. Hart and Strapp (*334*) discussed the correlation between commercially produced pulps and semicommercial pulps. Root (*335*) considered the theoretical and actual qualities of corrugated board. Nomura and Okada (*336*) discussed the cooking of screenings by the neutral sodium sulphite process. The Green Bay Paper and Pulp Co. (*337*) reported that caustic soda can be substituted in large measure for neutral sodium sulphite in semichemical pulping. Coker (*338*) described an early application of semichemical pulping.

Pulp and Paper (*339*) announced semichemical pulp made for sale. Marpillero (*340*) described the application of the semichemical process (so-called Abikraft process) to Asplund fibers. *Chemical Week* (*341*) announced recent gains in semichemical pulp tonnage. Agronin (*342*) discussed the combination of semichemical pulping with an existing stock preparation system. Petrie (*343*) proposed the combination of raw kraft pulping with hot-stock preparation. Klemm (*344*) considered the utilization of lignified fibrous pulps. Olson and Marteny (*345*), Runkel (*346*), and Hagglund (*347*) discussed various applications. Wright (*348*) described Florida's new process, and Grondal and Zenczak (*349*) discussed triethylene glycol as a pulping agent and some of the engineering problems involved. Textor (*350*) described the use of revolving double disk mills with semichemical pulping. Eberhardt described the use of similar equipment on straw (*351*) and for stock preparation in board mills (*352*). Small (*353*) described the application of single disk mills. Messing (*354*) disclosed a discharged device for an Asplund defibrator.

In the development of means for disintegrating semicooked pulps conventional and improved beaters were used to a considerable extent (*355–357*). The kollergang, refiner, and curlator also came into use (*358–361*). Williamson (*362–364*) discussed the various factors involved in beating and refining. Hot-stock treatment is more common (*365–370*). Keller and McGovern (*371*) showed that the impregnating liquors can be used several times before complete utilization of the caustic soda. The Bergström tower is shown to be useful in removing the sulphides and mercaptans as a step in recovery (*372*). Many new machines have been disclosed for separating the fibrous elements; for example, by Haug (*373, 379*), the Midwest Fulton Machine Co. (*374*), Messing (*375*), Coghill (*376*), and Arpin and Frye (*377, 378*). Arend (*380*) reviewed some of the improved pulping processes. *Chemical Engineering* (*381*) mentioned new processes and technology. Fortman (*382*), Donohue (*383*), Ernst (*384*), Kehoe (*385*), and Sivola (*386*) disclosed various processes.

The use of sawmill waste, bark, and sawdust has found an outlet in various molded and sheet products to an interesting extent. Elmendorf (*387*) has summarized 15 wonders that have appeared since 1920. Wilcox (*388*) reported the effect of machine speed, head, and specimen span on the modulus of rupture in static bending. The Technical Association of the Pulp and Paper Industry (*389*) has established a standard drainage time. Heritage (*390*) disclosed some fiber compositions for molding.. Weyerhaeuser (*391*) claimed the production of hot molded articles from sawdust. Bergström, Heijmer, and Trobeck (*392*) patented a method for making indurated boards from fibrous materials, and Wesner (*393*) a process for a sheathing board. *Paper Mill News* (*393a*) reported increases in the production of panelboard from forest products. Clark and Wells (*394*) disclosed a method and machine for the air-borne formation of fibrous sheets. Browne (*395*) proposed a method of making resilient batts and Heritage (*396*) one for the production of hot-bonded felts from air-borne fiber. *Chemical Processing* (*397*) assures asphalt coating makers a substitute for asbestos in Silvacon. Hergert and Kurth (*398*) discussed the nature of the cork in Douglas-fir bark, and Owens (*399*) disclosed the substitution of Douglas-fir bark for cork in insulation. Gottstein (*400*) reported synthetic resin combinations for hardboard manufacture, and Farber (*401*) discussed related factors. Swartz and Baird (*402*) reported on the effect of molding temperature on the strength and stability of hardboards from fiberized water-soaked Douglas-fir. Nordman and Gustafsson (*403*) discussed the relationship between strength and bonded area of paper and board. Farber (*404*) considered the condensation and hydration reactions of low-grade cellulosic materials in relation to their utilization. Siimes (*405*) reported the quantities of wood waste in the Finnish mechanical wood-conversion industry. Anderson and Runckel (*406*) discussed the utilization of Douglas-fir bark in hardboard. Heritage and Van Beckum (*407*) disclosed a process for producing lignin products, and Heritage and Walter (*408*) one for the manufacture of dry pressed felt. Evans (*409*) discussed hardboards made with a semidry process, and Ögland (*410*) the sizing of hardboards which had received a hot-air treatment after pressing. *Pulp and Paper* (*411*) listed the various United States agencies and officials concerned with price control, stabilization, materials allotment, economic cooperation, etc. *Paper Mill News* (*412*) announced more materials handling equipment in pulp and paper mills.

CONSUMPTION OF CHEMICALS

Paper Mill News (*413*) listed chemicals used in paper making. Borax Consolidated (*414*) discussed the use of borax. The Atlas Powder Co. (*415*) assured a stable supply of sorbitol. Stenerson (*416*) discussed the growing lack of balance of the use of chlorine and caustic soda in pulping. Reid (*417*) discussed the bleaching of kraft pulp with chlorine dioxide. Bishop (*418*) described kraft bleaching in four stages. Pye and Joseph (*419*) discussed the production of chlorine, and Eichenhofer and Fedoroff (*420*) the modernization of chlorine liquefaction by the use of Freon. Reichert, Pete, and others (*421*) considered materials of construction and the use of hydrogen peroxide in bleaching. Samuelson and Hartler (*422*) studied the effect of chlorine dioxide and chlorite bleaching on copper number, hot alkali solubility, and carboxyl number of sulphite pulps. Neale (*423*) discussed the brightening of eucalypt pulp by zinc hydrosulphite. *Chemical Week* (*424*) showed the reduction of sodium sulphate requirements from 241 lb. per ton of kraft pulp five years ago to 195 lb. in 1951. Stenerson (*425*) discussed soda ash requirements for 1953.

AGRICULTURAL RESIDUES AND PLANT FIBERS

Lathrop (*426*) enumerated the virtues of plant fibers in adding to the potential supply of paper fiber. Bhat (*427*) listed sources available in India, Engel (*428*) suggested fibrous materials from German plantations, and Aronovsky and Nelson (*429*) studied the rate of delignification, using the mechano-chemical process. Rankin (*430*) presented the benefits from cutting straw before pulping. Palm (*431*) described the performance at the Hinde and Dauch strawboard mill at Trenton, Ontario. Huguenot (*432*) discussed the mechanical devices and apparatus for the continuous treatment of straw, alpha, and other plants. Anderson (*433*) considered the protection of straw stacks with sisal. Lathrop, Naffziger, and Stivers (*434*) proposed wheat strawboard to replace veneer in wire-bound shipping containers. Adams and Castagne (*435*) described the hemicelluloses of wheat straw. Williamson and Lathrop (*436*) described hardboard from agricultural residues. Lathrop (*437*) pointed to the role of research in helping to solve the problems of the straw-

GROWING ASSURANCE

of a future supply of WEYERHAEUSER WOODPULP

As early as 1911, Weyerhaeuser Timber Company had plans to consolidate and hold large blocks of timber land for the growing of future timber crops. In 1924, the company employed experienced foresters to work out the details of these plans.

During the mid-thirties the development of a broad forestry policy proceeded at an increased pace. In 1941, the Clemons tree farm was established as the first of its kind. Thus began a nation-wide movement which recognized the fact that private owners of forest land could and must manage their lands for continuous production of forest crops according to sound forestry principles. Now, there are over 25,000,000 acres of such farms located in 35 different states.

Today, all of the Weyerhaeuser Timber Company's operating forest lands are divided into eleven tree farms containing over 2,500,000 acres of timber land. With a background of half a century in the timber business, Weyerhaeuser is now projecting its sustained yield forestry policy 100 years ahead! This is part of the company's *permanent production program* designed to provide a continuing and *increasing* timber supply for its mills.

board industry. The Northern Regional Research Laboratory (*438*) pointed out how restyling by-products will add new income. Nass (*439*) and Faldner (*440*) described the pulping of straw with liquors containing sodium sulphite. Faldner (*441*) also suggested means for reducing the cost. *Paper Making and Paper Selling* (*442*) believed an annual production of 500,000 tons of paper from straw is possible. Aronovsky (*443*) presented recent advances in pulping straw in the United States. Tabb (*444*) discussed experiences in Great Britain. Lathrop (*445*) discussed pulps from straw and bagasse in newsprint manufacture.

Pulps from sunflower stalks have been considered in Germany (*446*). Basu, Bhattacharyya, and Bose (*447*) described the multiple culture technique for testing the rot resistance of jute, and Basu and Ghose (*448*) the detection and estimation of damage in jute fiber. Macmillan and Sen Gupta (*449*) studied the effect of partial acetylation of jute. Sarkar (*450*) reported on the cellulosan of jute fiber and Sen Gupta and Callow (*451*) the progressive delignification of jute fiber with chlorine dioxide. Wright (*452*) discussed ramie fiber developments and Jensen (*453*) disclosed a process for degumming and bleaching ramie. Lafontaine (*454*) discussed the decortication and use of linseed flax fiber in papermaking. Hulfish and Waldo (*455*), Burkardt (*456*), and Wright (*457*) disclosed various decortication apparatus.

Southern Pulp and Paper Manufacturer (*458*) and Bailey (*459*) described the possibilities of Lespedeza including papermaking fiber.

Montessus de Ballore (*460*) described alfa and alfa paper and *Papetier* (*461*) and Legram (*462*) also discussed esparto. Partridge (*463*) gave some notions in connection with grass boiling, and Maronne (*464*) hints and hitches in the production of grass paper. Harrer (*465*) described the sisal industry, as did Gondhalekar (*466*), suggesting possibilities as a cottage industry. Harrer (*467*) discussed *Phormium tenax*, as did Critchfield (*468*) and McIlory (*469*).

Wakeham and Spicer (*470*) discussed the strength and weakness of cotton fibers, and Ernst, Sutcliffe, and Aronovsky (*471*) the utilization of cotton stalks. Joglekar and Donofrio (*472*) discussed dissolving pulp from bamboo and Thoria (*473*) the suitability of materials indigenous to India for dissolving. Aggarwala (*474*) described the bleaching of bamboo pulps. Ernst, Sutcliffe, and Aronovsky (*475*) described tests on crotolaria pulps; Das, Mitra, and Wareham (*476*) reported the composition of *Hibiscus cannabinus* and Chittenden and Coomber (*477*) studied the pulping of nipah palm petioles. Muck (*478*) discussed forest and climate protection through *Phragmites communis* and *Arundo donax* hybrid plantations. Morganti (*479*) announced fine paper manufacture from bagasse at Monte Alegre, Brazil, using the Pomilio process and *Business Week* (*480*) reported the successful use of bagasse in Peru. Lathrop, Aronovsky, and Naffziger (*481*) suggested increased profits from cane sugar by the utilization of bagasse and Aljian, Atchinson, and Lathrop are announced as being associated with the studies of its use by the Hawaiian sugar industry (*482*).

COOKING PROCEDURES AND DIGESTER FACILITIES

Instruments, level control indicators, automatic control thermostats, remote control switches, and instrument panels are more generally in use for facilitating the operation of the digesters. Keyes (*483*) discussed the subject together with positive circulation and indirect heating. Wilcoxson (*484*) has patented a use of heat exchangers and Lockman (*485*) disclosed certain features of heat exchange apparatus. Christenson (*486*) discussed continuous cooking and washing. Grand (*487*) considered improved methods and Michon (*488*), Briggs (*489*), and Boija (*490*) disclosed improvements in the field. Mannbro (*491*) discussed liquor recovery from digesters and diffusers. Morrison (*492*) considered the use of vacuum filters and Coghill and Langdon (*493*) and Nordengren (*494*) disclosed thickeners and filters; Miller (*495*) reviewed the general field of filtration. Armstrong (*496*) described a new screw press, Haug (*497*) disclosed machines for working paper stock, and Brax and Markila (*498*) described the M-B method for washing pulp in diffusers. Rushton (*499*) reviewed mixing, and Jones and Detcher (*500*) presented their studies on the use of ammonia base in neutral sulphite semichemical pulping.

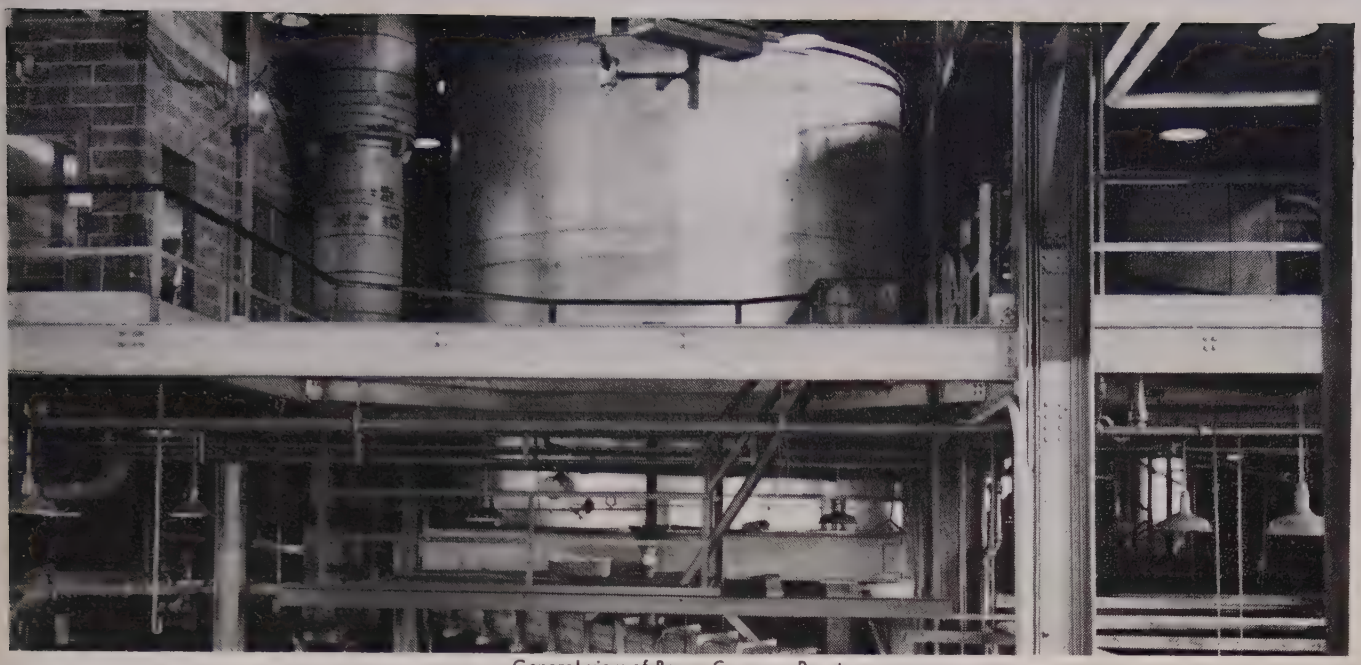
With the introduction of sulphur compounds into the formulation of cooking liquors, continuous washing, and other advances, increased maintenance cost has occurred, and the need for more resistant material has confronted the engineering staff of most mills. Teeple (*501–503*) discussed the problem and reported for the subcommittee on the subject appointed by TAPPI. Stockman (*504*) reported on the work of the Swedish committee, together with the Svenska Pappers- och Cellulosaingeniörsföreninen (*505*); Parker (*506*) presented the literature on corrosion. Graff (*507*) discussed the maintenance of recovery furnaces, flues, fans, etc., at Longview, Wash. White (*508*) reported the failure of a digester in Australia, Huseby and Scheil (*509*) the corrosion rate of the welds of sulphate digesters, and Day (*510*) its control in a chemical plant. Hair and Duskin (*511*) studied the possible effects of silicates on digesters, Flynn (*512*) considered digester corrosion, and Johnson and Gibson (*513*) considered the use of stainless steel linings.

TALL OIL, TURPENTINE RECOVERY, FOAM, AND FOAM CONTROL

Stenerson (*514*) indicated the expansion of tall oil recovery and its distribution in various products. Islip and Mathews (*515*) described slash pine oleoresin from British Honduras. Ball and Vardell (*516*) described the spectrophotometric analysis of tall oil rosin acids. Kirkpatrick (*517*) claimed chemical compositions from tall oil and a process for the preparation thereof. Burrell (*518*) disclosed tall oil-pentaerythritol ester resins modified with unsaturated acids. Hasselstrom and Stoll (*519*, *520*) have patented methods for producing and refining tall oil soaps. Gabrielson (*521*) gave the composition of tall oil and its distillation products. Stephenson (*522*) disclosed a process for making tall oil, Christenson and Harpt (*523*) the separation of tall oil components, and Linder (*524*) distillation and rectification columns and processes for use of such columns. Potts and Olson (*525*) disclosed apparatus for distillation of fatty acids, and Babayan (*526*) the cyclic reuse of cyclohexylamine in rosin acids separation.

Marling (*527*) disclosed a coating composition comprising the reaction product of vinyl esters of tall oil acids with a mixture of styrene and an isopropenyldiphenyl, and Hamm (*528*), a tall oil-melamine reaction product. Jordan and Herban (*529*) claimed a plastic tall oil rosin fraction, McCoy (*530*) a quick breaking bituminous emulsion, Rosencranse (*531*) an asphalt emulsion for the treatment of coal, and Sunnberg (*532*) a tall oil pitch. Nowak and Fischer (*533*) patented a method for preparing oil-soluble metal soaps, Hunn (*534*) a method for preparing aluminum and magnesium soaps and Olson (*535*) the preparation of metal-organic compounds.

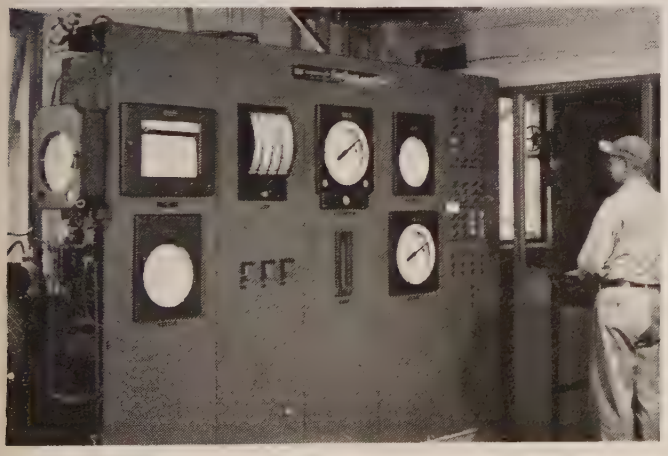
Ross and Young (*536*) discussed the action of antifoaming agents and Ross (*537*), the reason for foam. McGinn (*538*) disclosed defoaming agents, Morse and Moss (*539*) discussed defoamers, and Bikermann (*540*) the mechanical destruction of young and old foam films. McMurray and Moyer (*541*) disclosed the flotation of nelsonite ores, and Moyer (*542*) and Milliken (*544*) the flotation of ilmenite ores. The Tall Oil Association (*545*) discussed tall oil emulsions and Morway and Kolfenbach (*546*) disclosed lubricating grease containing soaps of tall oil. Richter and Miskel (*547*) claimed rubber-like polymers from acetylated tall oil, Simmers (*548*) a liquid binder for mineral wool, Williams (*549*) a lubricant metal-rolling composition, and Henkes (*550*) a well drilling fluid. Davis and Spurlin (*551*) disclosed a countercurrent separation



General view of Brown Company Reactor

First Dorrco FluoSolids* Reactor For Producing SO_2 Goes "On Stream" at Brown Company

BERLIN, N. H. In anticipation of a continuing sulfur shortage, The Brown Company at Berlin, N. H. recently installed a Dorrco FluoSolids System to produce SO_2 gas from pyrrhotite. The System at the present time is supplying the entire sulfur requirements of this sulfite pulp mill . . . 11,000 tons of sulfur equivalent per year. A producer of quality pulp for high-grade photographic papers, Brown requires clean, high-strength SO_2 gas to make their sodium sulfite cooking liquor.



Centralized control panel

RAW MATERIAL FORMERLY A WASTE PRODUCT

The pyrrhotite, recovered from tailings of a nearby copper mine, is received in a moist condition, repulped with water to 70-75% solids, and pumped into the Reactor. By operating close to theoretical oxygen requirements, the strongest possible SO_2 gas is produced, with a black magnetite calcine which is quenched and handled in slurry form. Roast is accomplished in a 16′ inside diameter Reactor with the temperature automatically held at 1650°F.

Clamshell discharging pyrrhotite into blunger

HIGH STRENGTH SO_2 PRODUCED

Gas strength at the top of the Reactor averages 13% SO_2. The gas then passes through a two-stage cyclone system followed by a cooling-scrubbing tower before going to the acid towers. Average chemical analysis of feed and calcine follows:

	Total Sulfur	Sulfide Sulfur	Total Fe
Pyrrhotite Feed	35.7	35.6	49.1
Combined Calcine	0.51	0.49	60.9

For detailed information about FluoSolids — a distinct departure from conventional roasters — write for Bulletin No. 7500. The Dorr Company, Stamford, Conn. or in Canada, The Dorr Company, 80 Richmond Street West, Toronto 1.

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process for tall oil, Dunlap and Sievert (*552*) the fractionation of oxidized tall oil with furfural, Van Valkenburgh (*553*) a composition of tall oil and a nonvolatile aromatic oil for compounding synthetic rubber, and Zeiss (*554*) the separation of rosin acids. Sandermann (*555*) discussed the refining of tall oil by distillation. Willamo (*556*) discussed the sterols in tall oil. Wilson (*558*) disclosed a method for producing alkylene oxide condensation products and Greenlee (*559*) a tall oil ester. Wallerstein and Alba (*560*) disclosed a method for the recovery of enzymes from aqueous solutions by means of tall oil derivatives. Smedslund (*561*) discussed the dimethyl sulphide content of sulphate turpentine and its recovery in pure form. Kobe and Romans (*562*) discussed the dehydrogenation of *p*-cymene. Collins and Patton (*563*) suggested a new method for the utilization of gum naval stores.

ANALYTICAL AND FUNDAMENTAL

Brauns' book on the chemistry of lignin appeared in 1951 and became available to research workers in pulping studies, recovery, papermaking, and practically all engaged in pulp and paper research (*565*). Heuser and Jørgensen (*566*) presented a comparison of fractional solution and fractional precipitation in the study of cellulosic materials. The annual rayon review appeared in *Textile Or'ganon* (*567*). Winding (*568*) discussed polymerization. Almin (*569*) discussed the modified cupriethylenediamine method for cellulose viscosity determinations, and Ellefsen (*570*), the sources of error in the calibration of capillary viscometers. Harwood (*571*) suggested its use as a reagent for the separation of hemicelluloses from wheat straw. Konow and Ant-Wuorinen (*572*) discussed the carboxyl groups in cellulose and Farrar, Neale, and Williamson (*573*) their gravimetric estimation. Sundman, Saarnio, and Gustafsson (*574*) discussed the carbohydrates in wood pulp. Smith (*575*) discussed chromatographic methods and their application to cellulose chemistry and Rockland, Blatt, and Dunn (*576*) small-scale filter chromatography and solvents. Samuelson, Gärtner, and Johansson (*577*) discussed ion exchange in alkali cellulose. Rånby (*578*) reviewed cellulose micelles. Centola, Pancirolli, and Borruso (*579*) discussed the characteristics of prehydrolyzed celluloses. Anderson (*580*) considered tracheid length variation in conifers as related to distance from the pith. Stewart (*581*) described an automatic sampler for paper mill use. Borlew (*582*) discussed problems related to the evaluation of pulping. Ritter (*583*) discussed the nondegradative oxidation of lignin sulphonates. Nethercut (*584*) discussed technical control of paper machine production and the Technical Association of the Pulp and Paper Industry (*585*) reviewed quality control. Yunker (*586*) reviewed the instrumentation of various pulping operations.

Alba (*587*) disclosed the isolation of enzymes from aqueous solutions and gelatin and the product obtained thereby. Anderson (*588*) described the use of lignin for golf greens and other horticultural uses. Kingsbury (*589*) discussed the determination of iron in wood and wood pulp. Greaves (*590*) discussed the use of wood bark as a source for tannin.

Csellak (*591*) reported on studies on the reaction between kraft black liquor and nitrobenzene and the formation of sodium *p*-azobenzenesulphonate. Trobeck (*592*) presented data on black liquor oxidation, and the British Columbia Research Council (*593*) on the reduction of odor from kraft pulp mills; Kress (*594*) disclosed a procedure for oxidizing black liquor constituents. Bozza and Colombo (*595*) discussed the elimination of odor from sulphate pulp mills, Bialkowsky and DeHaas (*596, 597*), the stabilization of Douglas-fir black liquor, and Wright (*598*), the degree of odor control in Canada. Wright, Schoening, and Hayward (*599*) outlined the colorimetric determination of hydrogen sulphide and methyl mercaptan in sulphate pulp mill effluents and sodium sulphide in black liquor. Lonngren (*600*) disclosed the art of treating black liquors and Savell (*601*) chemical recovery of kraft cooking liquor. Valeur (*602*) discussed the cooking of bleachable sulphate pulp. Ekman and Johnstone (*603*) discussed the collection of aerosols in a Venturi scrubber.

Van Beckum (*604*) disclosed a process for obtaining dehydroperillic acid from the alkaline extraction of lignocellulosic material, and Kurth and Hubbard (*605*) reported on the extractives obtained from ponderosa pine bark.

RECOVERY OPERATION AND EQUIPMENT

Fahlgren (*606*) described the use of the Jonsson screen on groundwood, chemical pulp, wastepaper stock, and straw stock, and Warren (*607*) discussed how to keep them at peak efficiency.

Badger and Lindsay (*608*) reviewed developments in evaporation in 1951. Storrow (*610*) discussed calculations for the balanced operation of a multiple-effect evaporator.

Hamm (*611*) disclosed design for chemical recovery furnaces. The British Paper and Board Makers' Association (*612*) reported on recovery and pulp evaluation. Vance (*613*) described the new recovery boiler for the New York and Pennsylvania Co. Sproull and Nakada (*614*) reported on the effect of temperature and moisture on the operation of Cottrell precipitators. MacMurray and Bryden (*615*) reported on some aspects of recovery in alkaline pulp mills. Hochmuth (*616*) disclosed a chemical feeder for black liquor recovery systems. Paren (*617*) proposed a method for spraying black liquor into the recovery furnace. Nielson (*618*) discussed progress in bark burning for steam generation. Krishnaswamy (*619*) discussed the importance of soot blowers for maintaining performance with Tomlinson recovery units. Hedlund (*620*) discussed the viscosity of concentrated sulphate black liquors at high temperatures. Mäkilä (*621*) discussed the reburning of lime sludge which is becoming a general practice. The Bird Machine Co. (*622*) presented modern practice in the filtration of lime sludge. Walker (*623, 624*) considered the operation of sludge recovery kilns and disclosed some improved practices. Murray, Fischer, and Sabean (*625*) discussed the effect of time and temperature of burning on the properties of quicklime. Saeman (*626*) considered the factors affecting the time of passage through a rotary lime kiln. Toch (*627*) discussed the operation and maintenance of the rotary lime kiln, and Vranian (*628*) the flash drying of the lime kiln feed. Roberts and Harper (*629*) showed the effect of the percentage causticity on the settling rate in causticization.

EFFLUENTS TO STREAM AND ATMOSPHERE

Rudolfs and others (*630*) gave a critical review of the literature of 1950 on sewage wastes treatment, and water pollution. Gehm (*631*) discussed planning for the handling of mill waste waters. Churchill (*632*) reported on the natural reduction of color from paper mills in streams. *Chemical Engineering* (*633*) discussed pollution control. Spencer (*634*) reviewed stream pollution laws in New York State. Eldridge and Orlob (*635*) gave the results of an investigation of pollution at Port Gardner and the Snohomish River estuary. Wadleigh and Simons (*636*) reported on the use of Waco filters for waste disposal at the Scott Paper Co. and *Paper Mill News* (*637*) presented the program. Driessen (*638*) disclosed a process for deinking printed wastepaper, and Massey and Goodwill (*639*) a method for deinking and bleaching wastepaper stock. Carey (*640*) reviewed sewage, river pollution, and trade wastes. Minute (*641*) reported on modern methods of cleaning paper stock. Baigas (*642*) discussed the advantages and disadvantages of paper machine white water utilization. Fennell (*643*) disclosed a method for recovering and bleaching wastepaper stock. Faldner (*644*) discussed the use of wetting agents in the regeneration of wastepaper. Palladino and Baigas (*645*) and Palladino (*646*) discussed the demonstration plant and the waste treatment plants at Plainwell, Mich., and at Fitchburg, Mass. *Pulp and Paper* (*647*) described the plant

FOR HIGH WET STRENGTH AT LOW COST

UFORMITE 711
A New Cationic Resin

Where high wet strength is needed at low cost—as in bag stock, toweling, and a host of other uses—UFORMITE 711 is your answer. This new modified urea formaldehyde resin imparts wet strength, and improves dry tensile, mullen, fold, pick resistance, and wet rub. It is adaptable to a wide variety of pulps from Kraft to sulfite-groundwood combinations.

In Wet-Strength Paper, UFORMITE Gives You Seven Important Advantages

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3. Ease of preparation—may be used as supplied or diluted readily with water, without acid addition or aging.
4. Addition at any convenient point—although headbox is preferred.
5. Effectiveness over broad concentration range—0.25 to 3.0 percent.
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7. Stability in storage.

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OTHER DEPENDABLE WET-STRENGTH RESINS

Rohm & Haas makes a complete range of dependable wet-strength resins:—UFORMITE 700, cationic resin for fast wet strength off the machine —UFORMITE 467, liquid anionic type for efficient, low-cost wet strength, particularly suitable for beater addition—UFORMITE 520, powdered anionic type corresponding to UFORMITE 467—and UFORMITE 471, liquid cationic type, suitable for all furnishes, any addition point. We'll be glad to mail you literature on these UFORMITE resins, also.

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CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

Representatives in principal foreign countries

of the Falulah Paper Co. Snow (*648*) reviewed some industrial waste plants in Connecticut.

Amberg (*649*) discussed factors affecting the lagooning of white water from board mills. Krancher (*650*) described the operation at Noblesville, Ind., and Knack (*651*) the operation at Monroe, Mich.

PURIFICATION AND BLEACHING

Casey (*652*) published Volume I of his "Pulp and Paper; Chemistry and Chemical Technology," in which purification and bleaching were discussed. Kraft (*653*) described the progress in pulp bleaching in America. Grant (*654*) discussed recent advances in bleaching and their significance in British papermaking. Herbst and Marshall (*655*) discussed the preparation and properties of neutral sulphite semichemical pulp from white birch. Montano and Hossfeld (*656*) described the reaction of wood with sodium hydrosulphite. McEwen, Sheldon, and Nelson (*657*) discussed hydrogen peroxide bleaching of mechanical and chemical pulps and new developments and process applications. Day and Hoos (*658*) and Collin and Jonsson (*659*) disclosed the bleaching of cellulose material.

Dennis (*660*) discussed the bleaching of eucalypt soda pulp and Neale, Pearson, and Somerville (*661*), the strengthening of eucalypt groundwood with alkalies and bleaching with hypochlorites.

Parsons and Lausman (*662*) described the bleaching of neutral sulphite semichemical pulp. Giertz (*663*) recounted some developments in bleaching processes, and *Canadian Pulp and Paper Industry* (*664*) announced that a Swedish bleaching process is used at Harmac.

Crowley (*665*) explained chlorine handling in pulp mills. Sevón and Sundman (*666*) disclosed a method for preparing chlorine dioxide gas, Haller (*667*) presented methods for analyzing chlorine dioxide and chlorites, and Brown (*668*) reported on the thermal decomposition of chlorine dioxide.

Chemical Week (*669*) reported progress with peroxide and Shanley (*670*) reviewed hydrogen peroxide.

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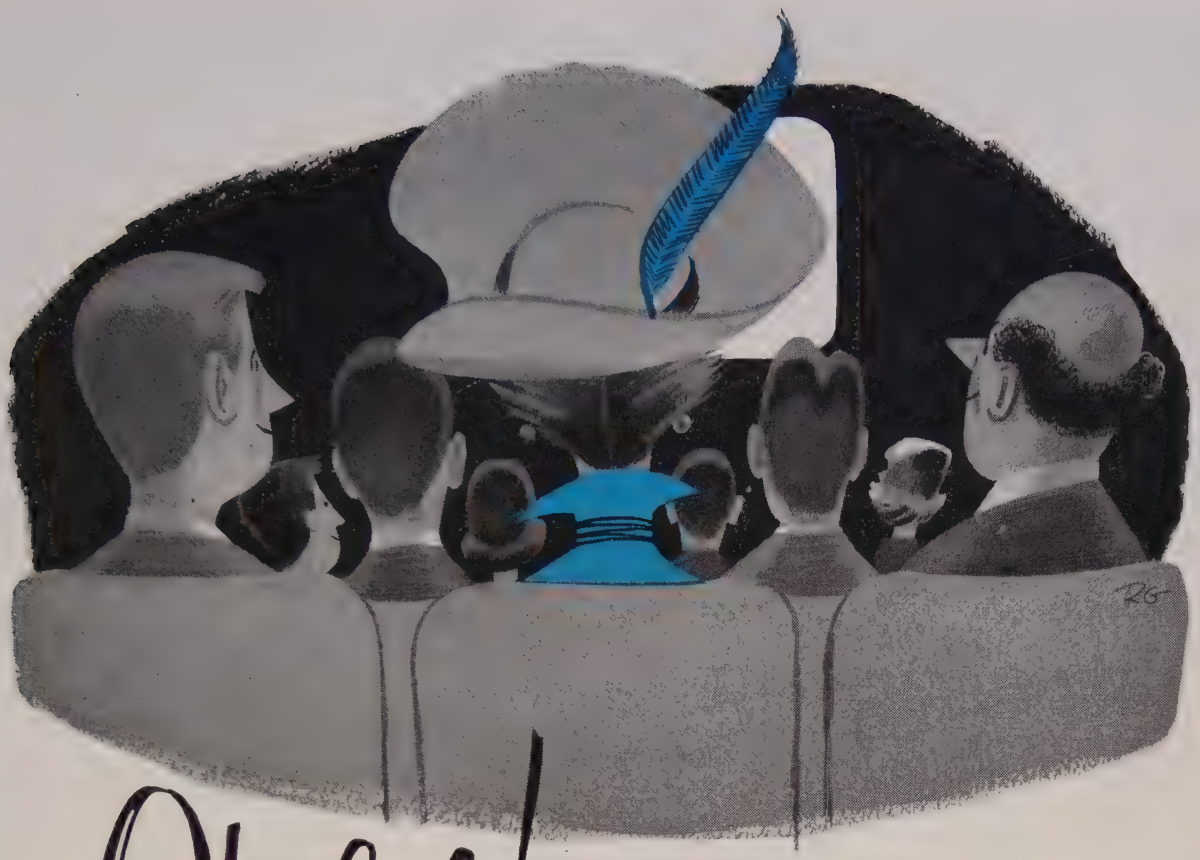

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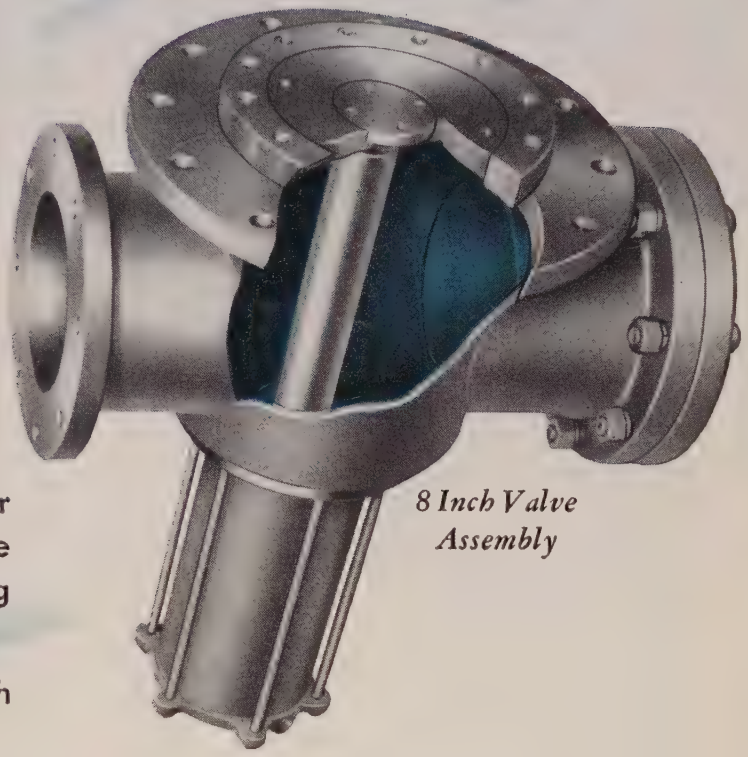

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Answering a need for a superior dump valve for the paper industry, Rice Barton Dump Valves have the following advantages:

- Passages of valve are clear, smooth and unobstructed.
- Plug type flange used to eliminate any stock accumulation in valve.
- Gate of valve flush with floor of tank which prevents unpulped stock from pocketing above valve.
- Valve may be opened and closed from a remote location handy to operator.
- Either water or compressed air may be used for actuating valve.
- Discharge in any direction by swinging valve on bolt holes.

Construction — Valve body available in either cast iron or bronze.
Trim of bronze or stainless steel.

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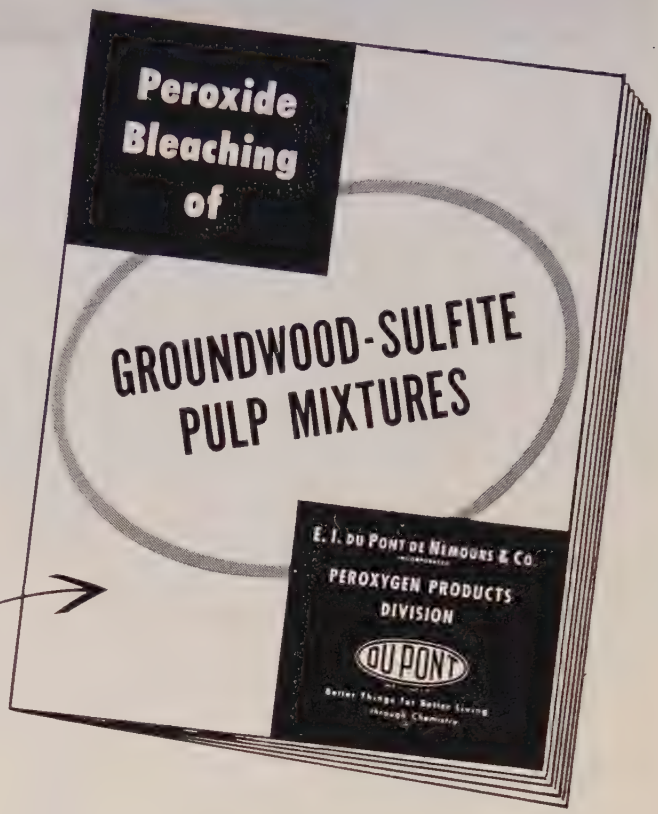

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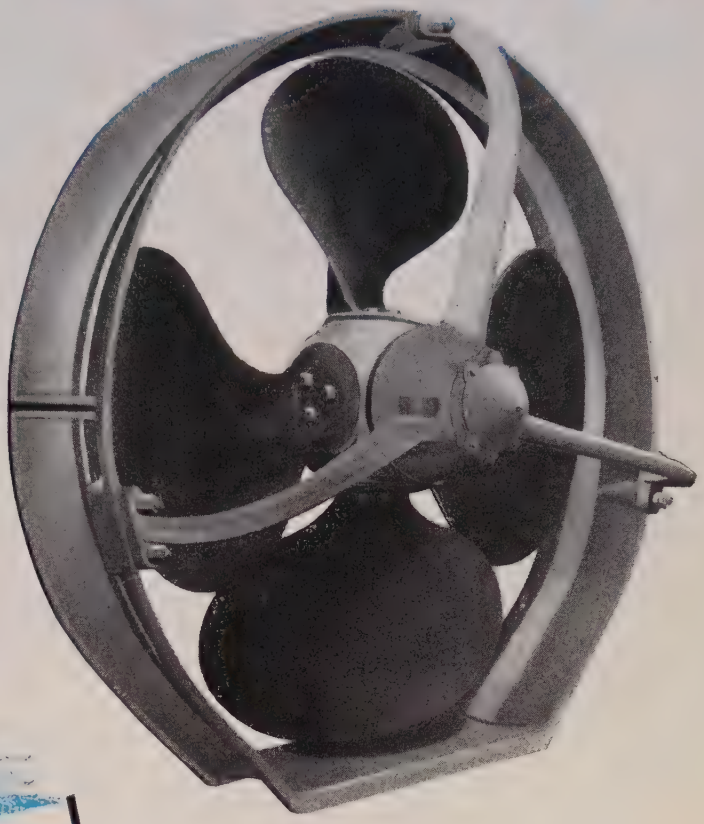

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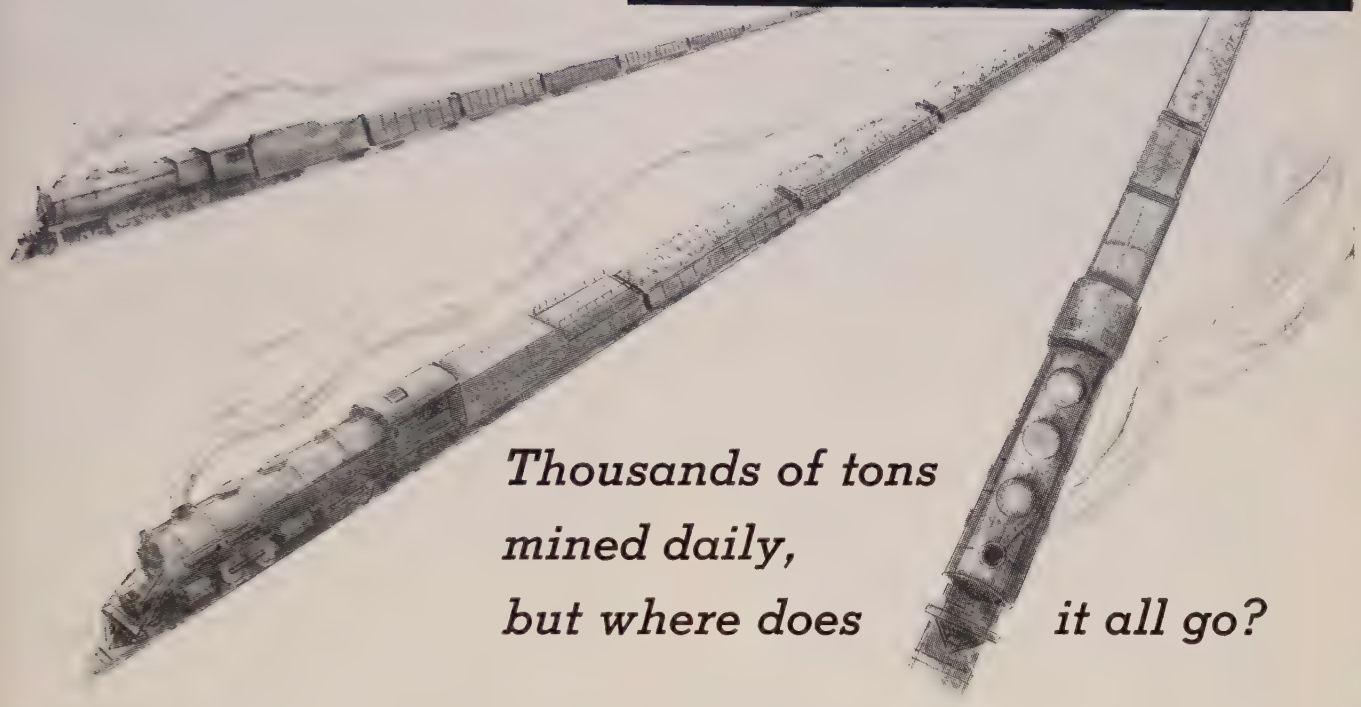

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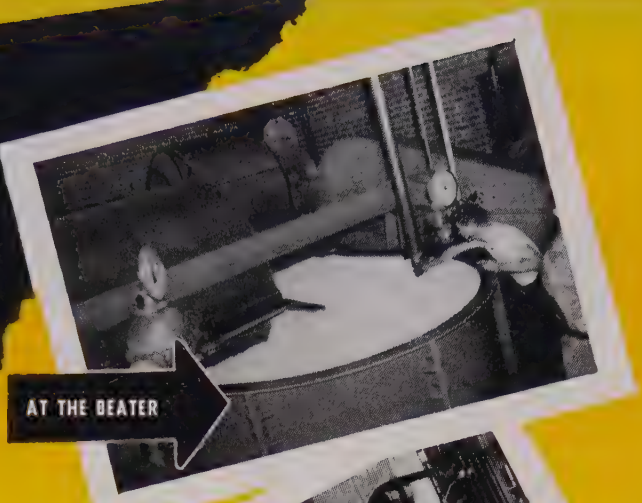

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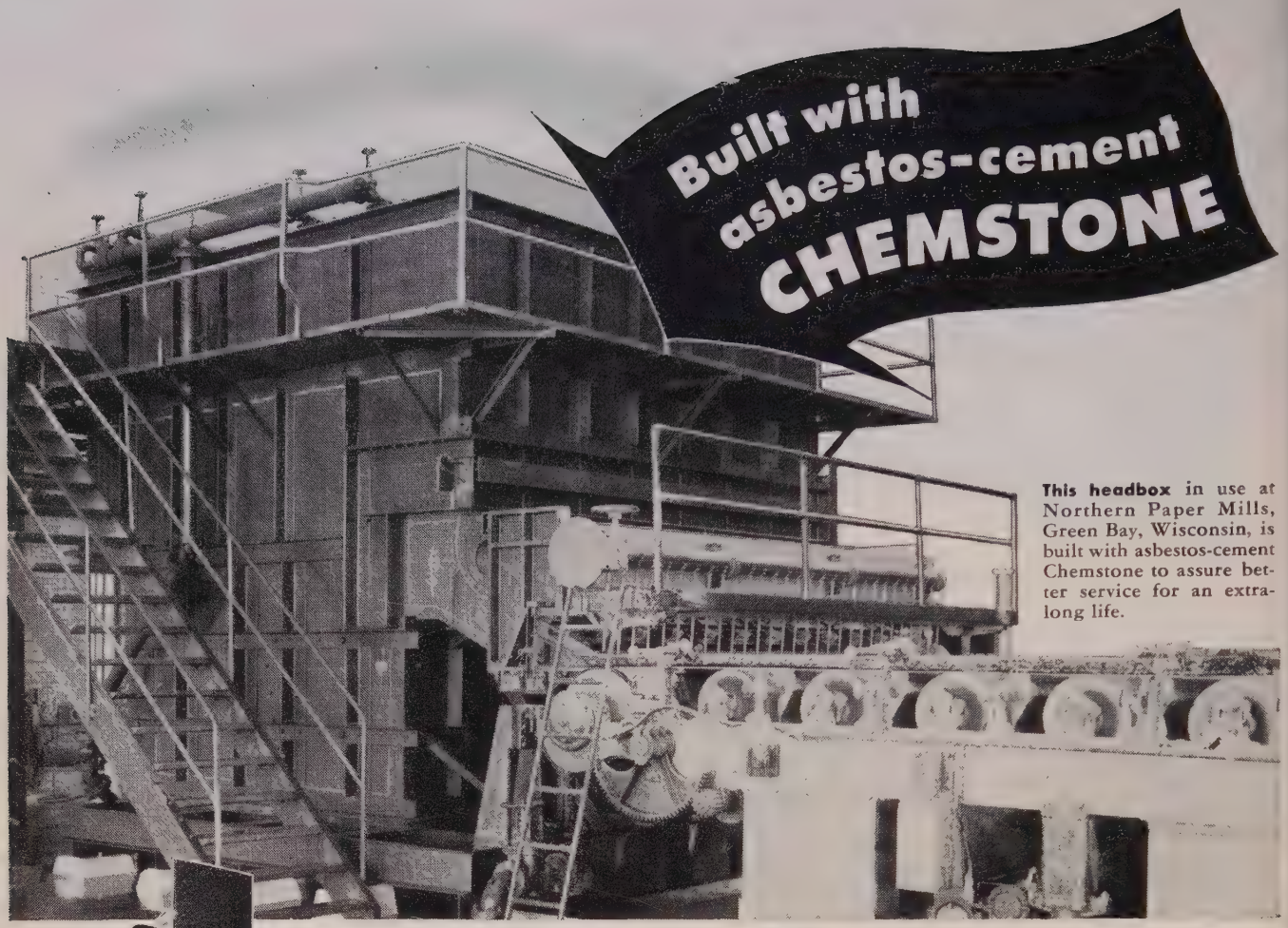

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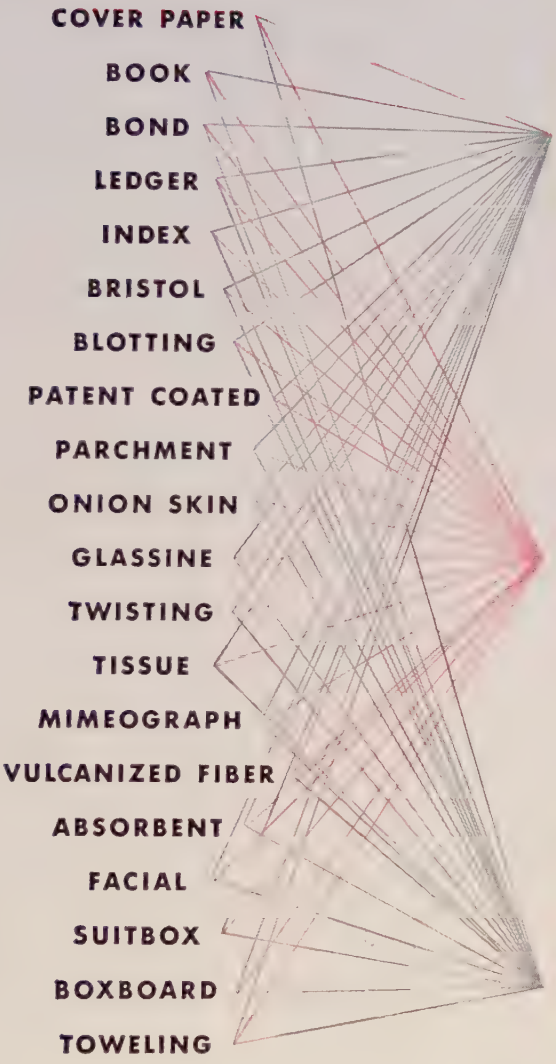

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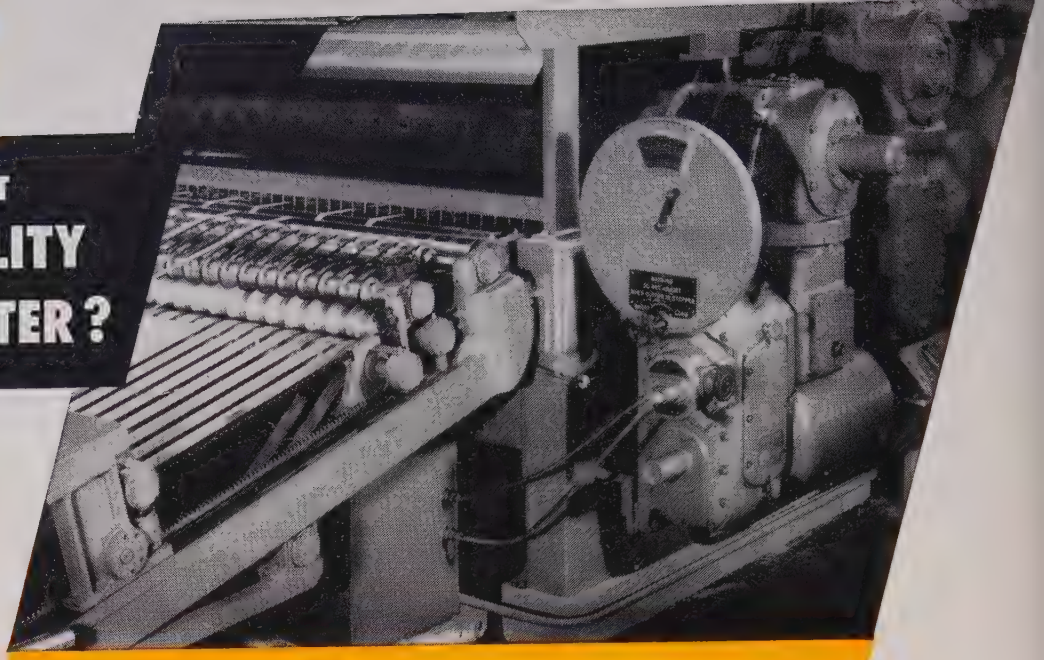

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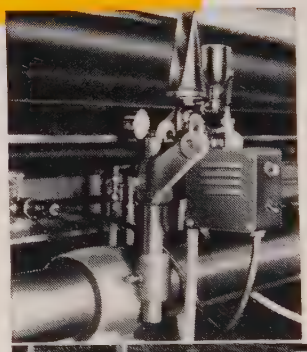

(Above) automatic counter installed on a Downingtown Masson-Scott Super Cutter. (Below) Backstands with tension and positioning devices.

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Pneumatic Conveyors in Pulp and Paper Mills

H. A. STOESS, JR.

Pneumatic conveyors are being used more extensively throughout the industry because of today's trend to higher labor costs for the purpose of cutting these costs to a minimum. Also, economic inter-plant material handling is conducive to the lowering of the costs of the ultimate product. For this discussion these conveyors are classified into their respective uses in pulp and paper mills for the unloading of the bulk chemicals required by the particular type of mills. The discussion includes the application of pneumatic conveyors to the handling of wood chips, and, to the unloading and reclaiming of bulk chemicals, together with their advantages and disadvantages.

Pneumatic conveyors are used in many operations in pulp and paper mills, including the transporting of chips from the wood room to the chip loft, and, for the unloading and reclaiming of various chemicals. In the pulp mill, these chemicals include pebble lime, salt cake, sodium sulphite, and soda ash. In the paper mill, these chemicals include loading (filler) and coating clays, starch, and gypsum. Other materials, including titanium dioxide, and other pigments, which are being used more often, can also be handled with a pneumatic conveyor.

As its name implies, pneumatic conveyors use air as the conveying medium. For the conveying duct, schedule no. 40 steel pipe is usually used. Movement of the material is brought about by a high velocity air stream, in which the material remains suspended, until discharged into a receiver, filter, or any other collecting medium.

Figure 1 shows the most common application of a pneumatic conveyor. This conveyor is of the vacuum, or, car-unloading type.

Its simple form as shown here, comprises an exhauster, used to produce a partial vacuum (usually 6 to 11 in. Hg) in a cloth-tube continuous filter which will give 100% visible retention of dust. The recommended type of filter has a cyclone separator bottom section in which most of the material is separated from the air stream and discharged through the airlock at the bottom of the filter. The dust remaining in the air stream is then carried up to the filter section where it is entrapped with the clean air passing to atmosphere through the exhauster. The filter section has four compartments one of which is cut out of service for approximately 15 sec. every 2 min. for cleaning the cloth filter bags through mechanical shaking action and reversal of air flow. This filter is required when handling dusty materials, but if nondusting materials are being handled, a two-stage receiving cyclone can be used. This filter is most suitably located in a position above the receiving bin, or bins, to permit delivery by gravity spouts, or by simple pneumatic or mechanical distributing conveyor to closely grouped storage bins. Small diameter (5 to 8 in.) conveying pipe, leading from the points of pickup to the filter, provides economical and convenient means for transporting the materials for considerable distances without interference from intervening structures, railroads, or passageways.

In Fig. 2 an operator is shown in the car unloading a material such as loading and coating clays, soda ash, and other materials which are not free flowing. Note that manual labor is kept to an absolute minimum, and dustless operation is accomplished.

As indicated in Fig. 1, Fig. 3 portrays a specially designed twin-nozzle attachment that is provided for materials received in hopper bottom cars. This device is placed underneath the car, and across, and resting on the rails. Attachment to the car hoppers is made through a flexible canvas connection by use of quick-detachable clamps. There is no dust or loss of material since the slide gates on the bottom outlets of the car are not opened until connections are made, and the system placed in operation. The same flexible hose used here is also used for the unloading of box cars with the use of a fan-type nozzle.

Advantages of pneumatic conveyors are cleanliness, freedom from dust, low handling loss or shrinkage, good labor relations, and, accessibility. Disadvantages are higher power cost (usually 25 to 50% more than other types of conveyors), higher capital investment (although only pneumatic conveyors are suitable at times), and unidirectional. However, experience has, in a majority of installations, found that the advantages far outweigh the disadvantages when comparing pneumatic conveyors with other types. This, of course, is dependent upon the requirements.

For pulp mill requirements we will consider first the conveying of wood chips.

In the wood room we are all cognizant of the three factors in its operation—wood economy, cleanliness, and labor economy. For wood economy this is dependent upon forestry operations and the proper selection of chippers and screening equipment. For cleanliness and labor economy a pneumatic conveyor is a distinct asset.

The pneumatic conveyor is used here to convey the chips as they are discharged from the screen and conveyed to the chip lofts above the digesters as indicated in the flow diagram in Fig. 4. The chips, upon discharging from the screen, are collected in a surge hopper and then passed on to the conveying duct through a feeder or airlock. This unit is either a vertical or rotary type depending upon the capacity required of the system. The blower recommended is the positive pressure type since operating pressures vary from 4 to 6 p.s.i. From the point where the chips enter the conveying duct below the feeder, they are blown to the chip loft. At this point a cyclone separator is recommended. However, in some installations, chips are delivered directly to the bins although this has the objection of being dusty.

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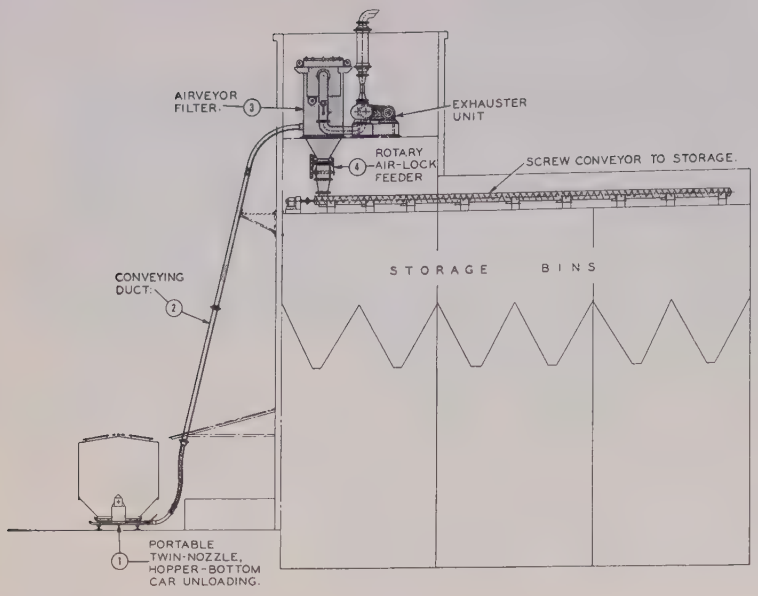

Fig. 1

One chip-handling installation such as outlined has been in operation over 16 yr. This system has been averaging 20 cords per hour of softwood (75% spruce) and, requires from 70 to 90 brake h.p. for operation. When this system was first installed, a centrifugal-type blower was used, and this blower used 120 brake hp. With this centrifugal blower the system tended to plug, but no trouble due to plugging has been had with the positive pressure blower since it was installed. Maintenance costs have not been excessive with the largest item being the replacement of conveying line bends. Some trouble, although minor in nature, has been had with the feeder or airlock. This could not be too serious, because there has not been a major shutdown of the wood room because of the failure of the pneumatic conveyor. A major point in this installation was the elimination of a fire hazard.

In the handling of wood chips one other operation might be mentioned here. This is the unloading of chips from trucks, railway cars, and barges. This is entirely feasible, but its success depends on a great amount of manual labor in getting the chips to the intake nozzle. Once the chips are within the range of the pickup nozzle, their conveyability is excellent. This type of system is the vacuum type where the chips are conveyed by suction to a point terminating in a cyclone separator.

In the unloading of pebble lime from box cars, Fig. 5, or hopper bottom cars to storage bins above the lime slackers not only for the recausticizing equipment, but for other purposes, the vacuum type of system is always used. This is another typical pneumatic conveyor, unloading from cars, and delivering directly to storage bin with the slacker below the bin for gravity feed.

Figure 6 shows a lime unloading system where Dorr recausticizing equipment is being installed in an existing mill. Space adjacent to the railroad siding is utilized by other equipment, and it was necessary to place the recausticizing equipment at some distance from the railroad siding. It is here that a pneumatic conveyor is ideal for the unloading of the pebble lime from cars and delivering to the storage bin above the slacker of the recausticizing plant. The conveying distance of the installation is approximately 275 ft. with the lime being unloaded at the rate of 15 tons per hr.

For the unloading of salt cake from box cars to storage bins and for reclaiming from the storage bin to process bin in the recovery building, the pneumatic conveyor is also well suited. Prior to the advent of materials such as "Orlon," bag filters could not be used due to the acid content in many of the salt cakes being used. Air washers in series with two-stage cyclone receivers were the accepted method, but these were not too satisfactory.

However, the salt cake that is received should be tested for pH in order to make the proper selection of the filter cloth. In the testing of representative samples, the pH varied from 4.01 to 9.91, using 1 gram of salt cake in 100 ml. of distilled water at 30° C. It can readily be seen that some salt cakes are acid and some alkaline when the neutral pH is 7.0.

Figure 7 shows a system unloading salt cake from

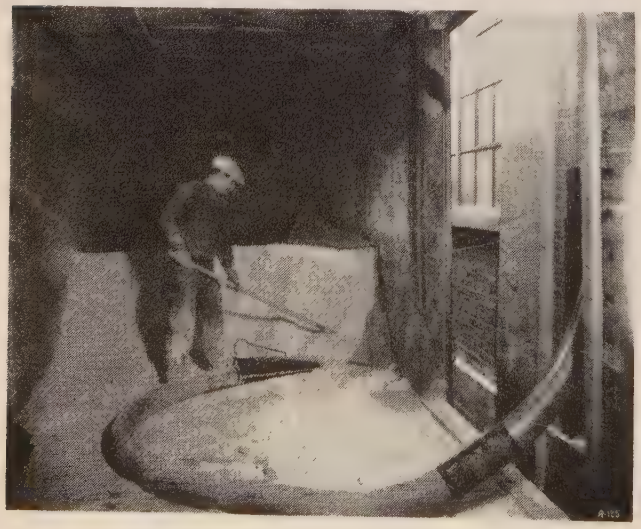

Fig. 2

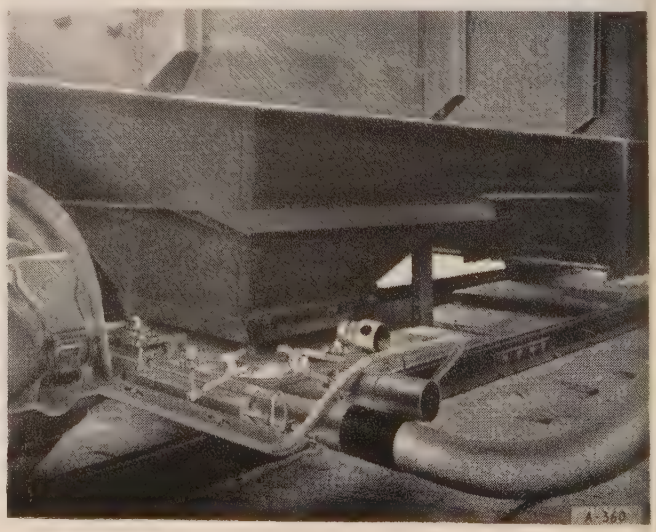

Fig. 3

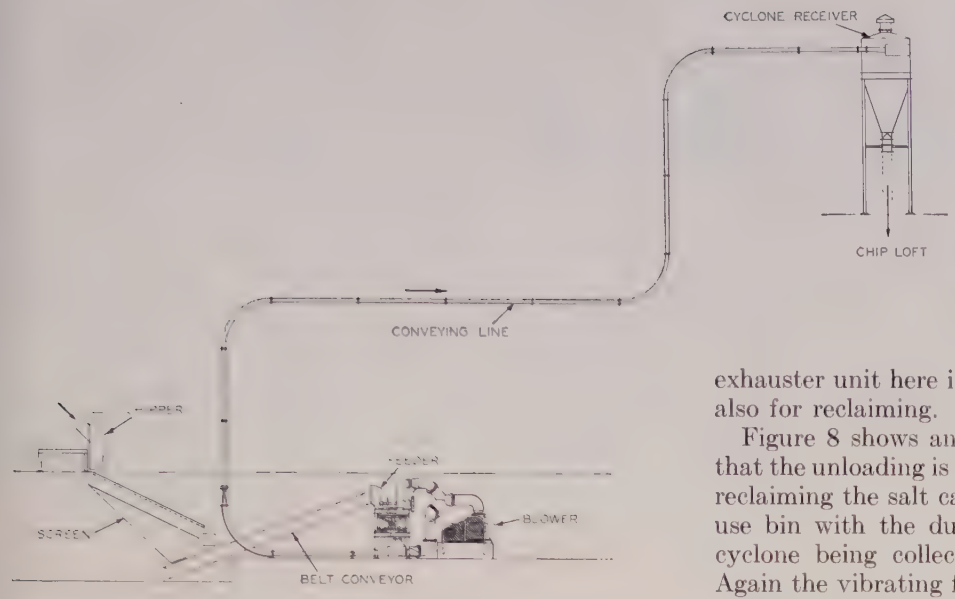

Fig. 4

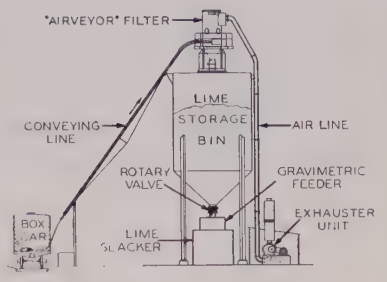

Fig. 5

box cars to either of two storage bins through a cloth bag filter with distribution to the second bin through a screw conveyor. From the bottom of the bins the salt cake is reclaimed and delivered to the surge bin above the mixer and adjacent to the recovery furnace. In the reclaiming of salt cake vibrating feeders are used below the storage bins for withdrawal. These are necessary due to the possible lumping of the material within the bin. After withdrawal by the vibrating feeder, the material is then passed through a swing hammer pulverizer, delivering a minus $^1/_8$-in. product to the recovery building. This, as far as can be found out, is standard procedure in the pulp mill. Note, that the exhauster unit here is used not only for unloading, but also for reclaiming.

Figure 8 shows another type of salt cake system in that the unloading is the same type of system, but in the reclaiming the salt cake is conveyed by pressure to the use bin with the dust emitting from the single-stage cyclone being collected by the Cottrell precipitator. Again the vibrating feeder and pulverizer are used.

Figure 9 shows another arrangement for unloading salt cake and pebble lime from box cars into either of two storage bins using a single exhauster unit to activate both unloading systems. For the smaller mill this is an ideal arrangement. Here is a system where an air washer was used on the salt cake system, and, as stated previously, cloth-type filters are now used.

For paper mill requirements, we find that pneumatic conveyors unload and reclaim coating and loading clays, starch, and talc, and other materials. In the conveying of loading and coating clays, the moisture content of the clays has a distinct relation to its conveyability. Usually clays having a moisture content of up to and including 5% will convey very nicely. When the moisture content is above 5%, the capacity of the system will be reduced 10 to 15% for each additional per cent of moisture.

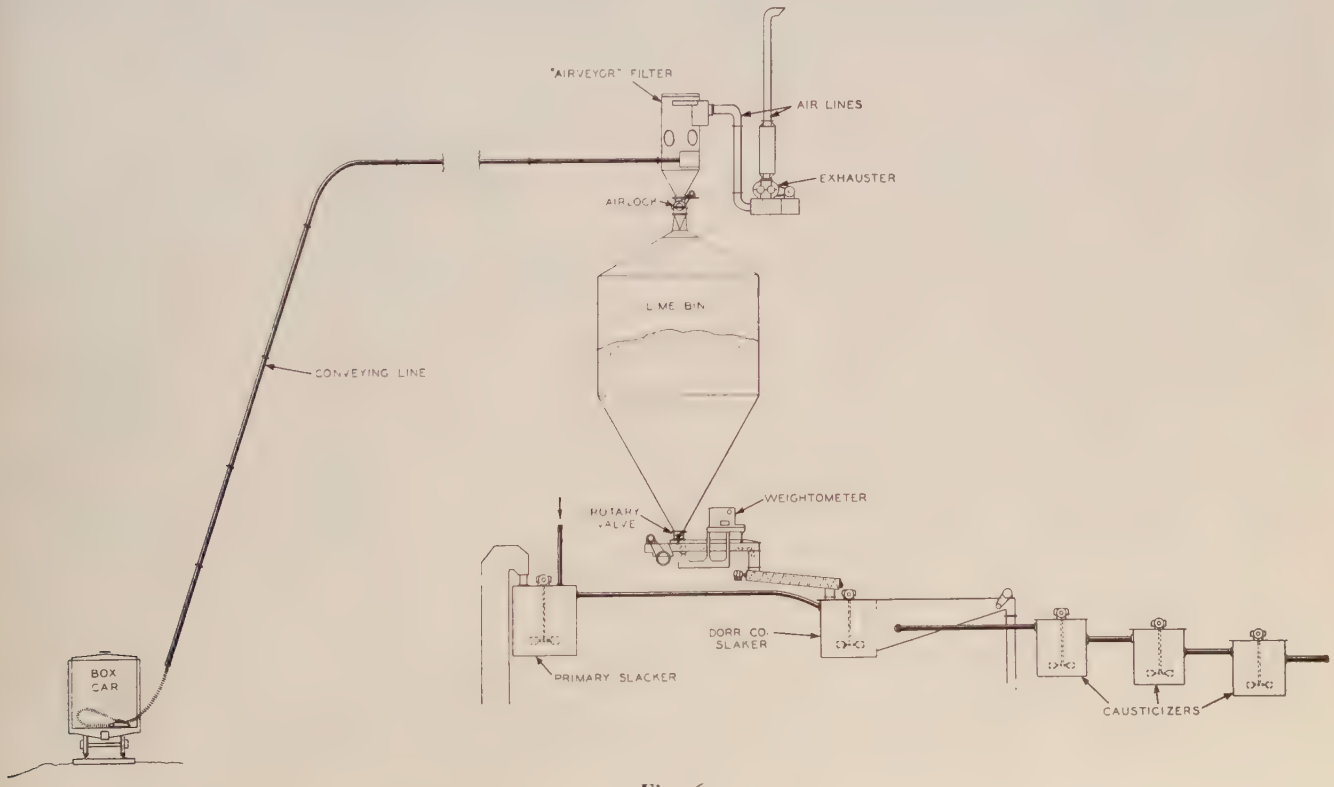

Fig. 6

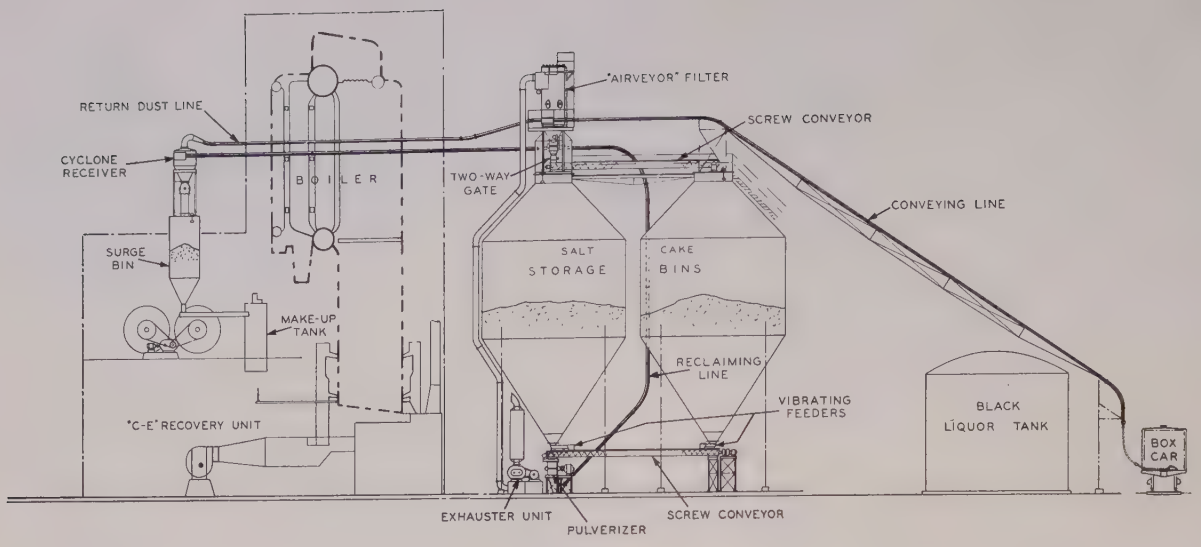

Fig. 7

The system in Fig. 10 unloads coating clays from either of three car-unloading positions, and, it will be noted that there are two systems involved. The one system unloads from cars and delivers to either of the two storage bins or reclaims to one group of weigh hoppers. The other system unloads direct from cars to weigh hoppers and also reclaims from the two storage bins. Pneumatic conveyors have been used in this plant for the last 20 yr. in their unloading operations.

The system in Fig. 11 unloads loading clay from box cars and delivers directly to either of two storage silos. Reclaiming of the clay from the silos is delivered to the weigh hopper above the mixer with the small amount of dust that passes through the two-stage cyclone receiver above the weigh hopper returning to the filter above the storage silos, thereby eliminating any loss of dust. Note that here, one exhauster unit is used to do both the unloading and reclaiming.

The system in Fig. 12 unloads clay from railroad cars and delivers to storage bins through a mechanical distributing conveyor, and reclaims from storage bins and delivers to the mixers.

On the reclaiming of clay, the clay is withdrawn from the storage bins through rotary feeders with aeration units and spike agitators in the bottom cone of the storage bin to prevent arching, and to accelerate the flow of material out of the bin.

For preliminary power requirements of pneumatic conveyors, the conveying of wood chips from wood room to chip loft requires approximately $2^1/_2$ hp. per ton of chips conveyed per hour. For the unloading and reclaiming of the various chemicals, etc., the power requirements will vary from 4 to $7^1/_2$ hp. per ton of material conveyed per hour. These figures will all vary according to the conveying distances involved, materials being conveyed, and the capacity of the system.

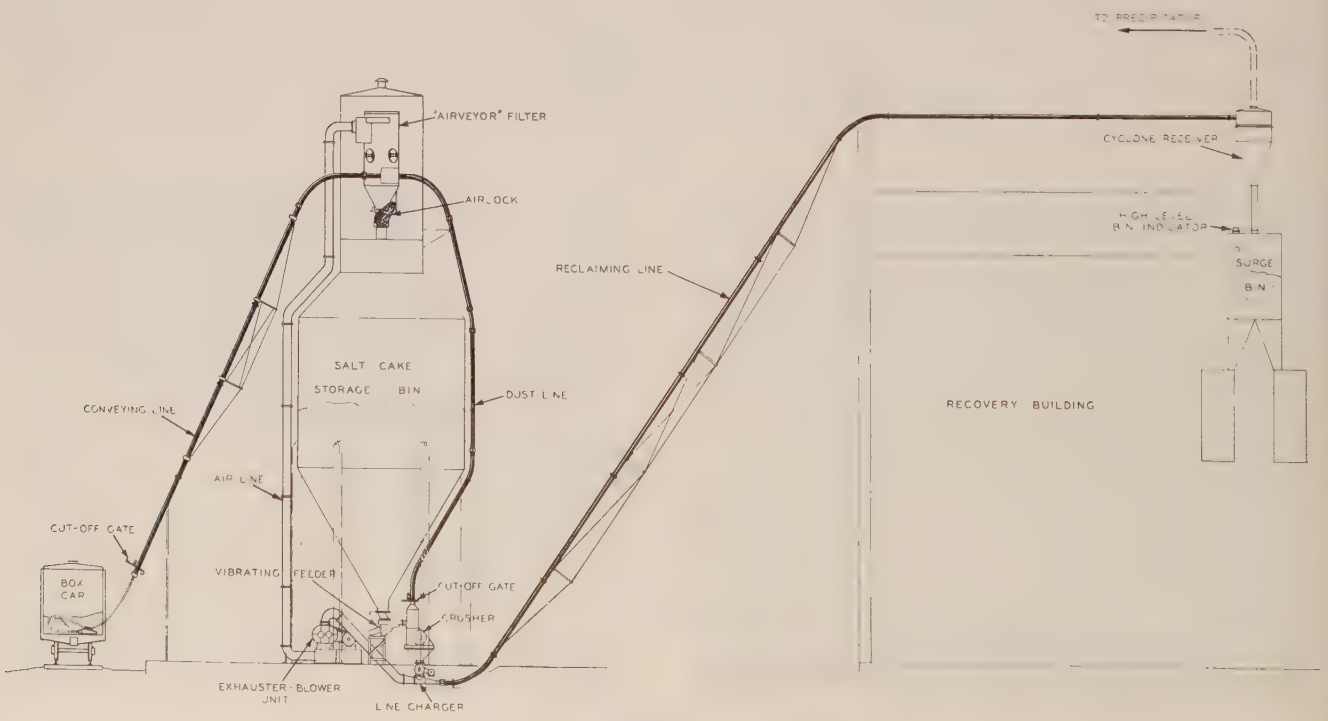

Fig. 8

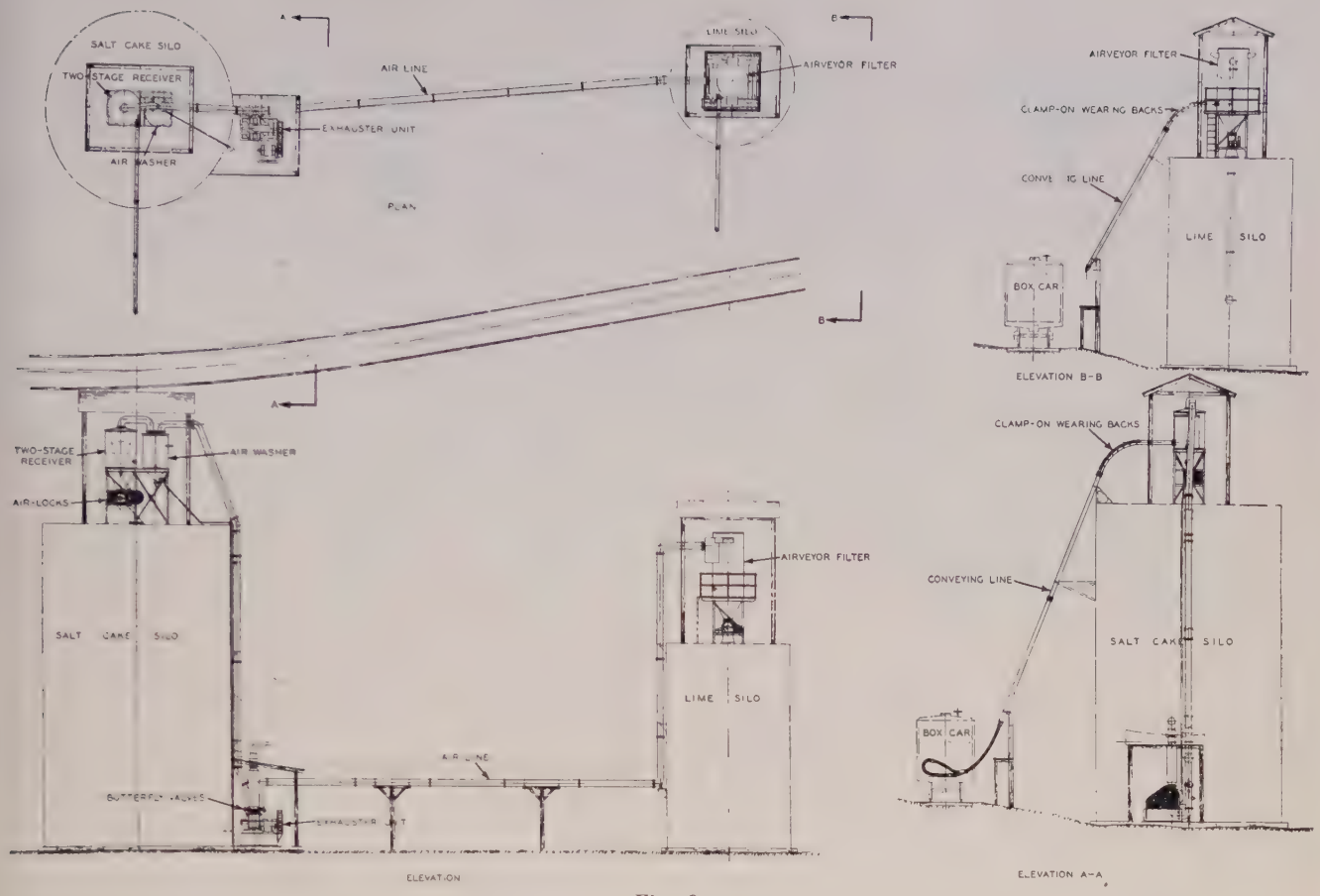

Fig. 9

In the matter of design manufacturers of this type of equipment have been criticized for the withholding of information. This is not a selfish attitude. Much effort has been spent in attempting to correlate information that would permit the design of pneumatic conveyors by formulas. The result of this effort was unsuccessful because of the infinite variability of physical characteristics of materials and arrangement of equipment.

For the pulp and paper industry these same variables appear in the conveying of materials such as clay, salt cake, and others. Clays, for instance, are produced in a wide variety of physical characteristics. Bulk density will range from approximately 20 to 50 lb. per cu.

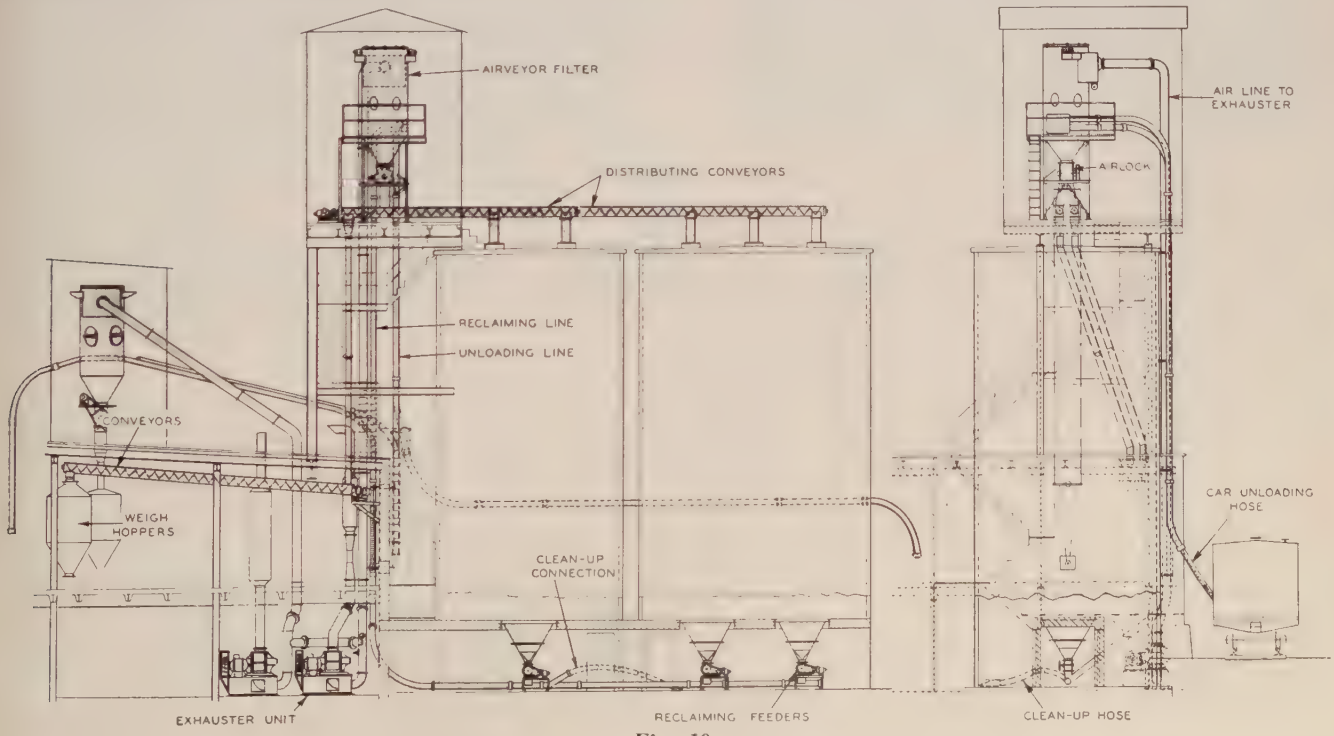

Fig. 10

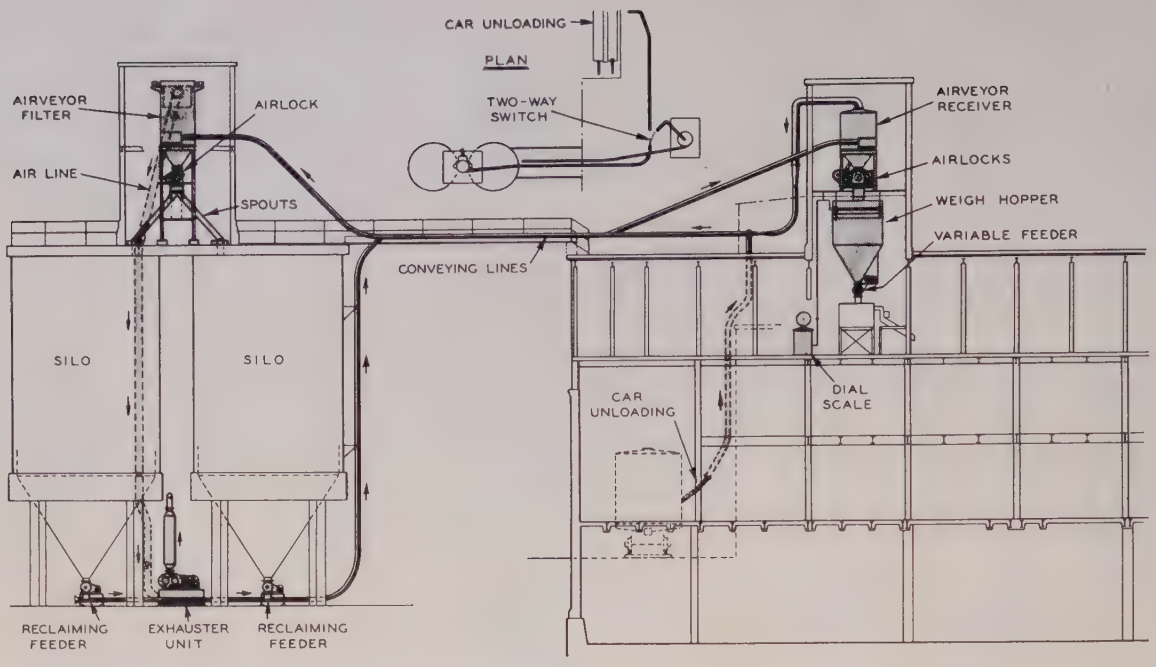

Fig. 11

ft. Moisture content will vary from 1% up to the point where pneumatic conveying becomes impractical. Salt cakes are also subject to variations. Bulk density will range form 70 to 95 lb. per cu. ft. Fineness ranges from pulverized through granular to lump. Of course, plant layout and capacities introduce further variables in every installation:

For the system in Fig. 5, a 50-hp. motor driving the exhauster will unload 10 tons of pebble lime per hour through a 6-in. conveying line 75 ft. long and a 5-in. unloading hose. A similar system (Fig. 6) unloading the same type of pebble lime at 15 tons per hour through an 8-in. conveying line 275 ft. long and two 5-in. unloading hoses, requires a 100-hp. motor for driving the exhauster. Note that only experience would tell us that with three and one-half times the conveying distance and 50% greater capacity that the system would require 100% more power, 80% increase in conveying line area, and two unloading hoses. Confronted with this situation, we find the only reliable method of engineering pneumatic conveying systems is the empirical one based on total past experience.

In the selection of the proper equipment for the various operations, we believe it best that the manufacturer be allowed free rein. His experience is long and varied, and he is a specialist. His success is based on the number of successful and satisfactory installations, and that his responsibility not only covers the furnishing of the equipment, but also its operation to the complete satisfaction of the mill operators.

Pneumatic conveyors have their advantages and disadvantages, and there are times when mechanical or other equipment is more suited for the job. Rest assured that the responsible manufacturer will only recommend pneumatic conveying where it has its advantages. In the unloading of the various pulp and paper mill chemicals, the pneumatic conveyor surely is a requisite due to its inherent advantages.

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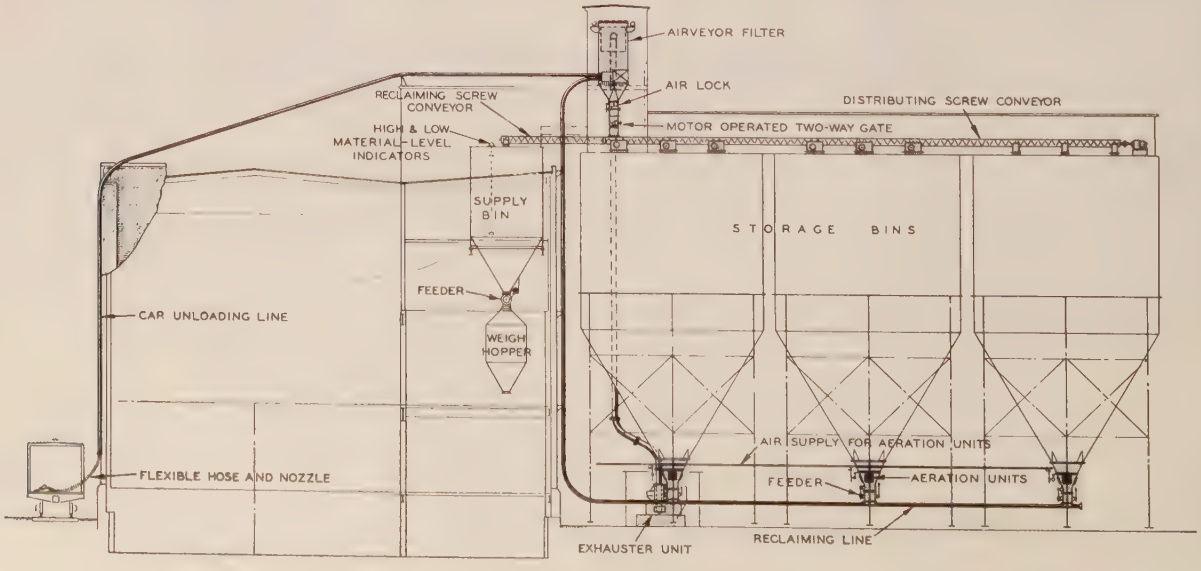

Fig. 12

An Investigation of the Mechanism of Water Removal from Pulp Slurries

WILLIAM L. INGMANSON

An equation expressing the filtration resistance (defined according to conventional concepts of average specific resistance) of compressible materials as a function of specific surface, effective specific volume, compressibility, and frictional pressure drop was derived. The basic assumption in the derivation was that the classical Kozeny-Carman equation, designed for use in static studies, would apply to the dynamic case of a constant-pressure filtration provided it was written in a differential form and properly integrated. By the combined use of experimental data obtained in dynamic and static studies of bleached sulphite pulps, the validity of the integrated Kozeny-Carman equation was established. It was concluded that average specific filtration resistance is directly proportional to the product of the Kozeny constant and the square of the specific surface, and is related to the frictional pressure drop by a complex porosity function which is dependent upon the effective specific volume and the compressibility of the material in question.

MANY important phases of papermaking are concerned with the removal of water from pulp slurries. Some of these operations, which are essentially an application of filtration, are the formation of the sheet on the paper machine wire, washing of stock after cooking and bleaching, recovery of fiber from white water, and various stages of deckering and thickening.

One of the very real needs of the industry is an understanding of the mechanism of water removal from pulp slurries. Several investigations of some of the factors affecting drainage as measured by a freeness or drainage time test have been carried out. These works have not provided fundamental information concerning the mechanism of drainage from pulp suspensions, but have served to point out the many undesirable features and doubts associated with the present instruments. The need of a fresh approach to the problem is indicated whereby the effects of the variables of drainage can be evaluated in a manner which will furnish a basis for general application of the knowledge obtained.

In recent years the understanding of the basic mechanism of filtration and fluid flow through porous beds has been advanced and unified considerably by the derivation and substantial experimental validation of equations, such as the familiar Kozeny-Carman equation, which relate the classical concept of filtration resistance with important particle properties such as shape, specific surface, and specific volume. Highly compressible materials, such as cellulose fibers, present a unique problem in attempts to relate filtration resistance with the variables involved in the Kozeny-Carman equation, mainly because of a variation in bed porosity throughout the bed under any dynamic (filtration) conditions. However, consideration of the nature of the equations involved led to the belief that the proper application of the Kozeny-Carman equation would, perhaps, provide a sound basis for a fresh attack on the general problem of developing our understanding of the mechanism of water removal from pulp slurries.

The aim of this study was to develop the necessary mathematical relationships and to obtain direct experimental data to substantiate the viewpoint that, under the proper conditions, dynamic filtration principles may be related to the important fiber properties of specific surface, effective specific volume, and compressibility.

FILTRATION THEORY

The mathematical aspects of the filtration theory were presented originally by Lewis and Almy (*1*), Sperry (*2*), and Ruth, Montillon, and Montonna (*3*). Carman (*4*) has presented a critical review of the fundamental principles of filtration, and Heertjes (*5*) has prepared a review of methods of correlating and analyzing filtration data and of the nature of specific filtration resistance. Filtration formulas based on the well-proved concept of specific resistance are summarized in reference books (*6–8*) and are similar in form to those presented here.

The usual filtration equation is based on a simplification of Poiseuille's law, and assumes that the volumetric rate of flow is equal to a driving force divided by a resistance (R). The equation holds only for streamline flow conditions and may be written in differential form as

$$dV/d\theta = A\Delta P_f/\eta R \qquad (1)$$

where V is the volume of an indifferent noncompressible fluid flowing in time θ past a cross-sectional area A. The frictional pressure drop across the bed is ΔP_f, and η is the fluid viscosity. The complete list of symbols used throughout this work is given in Table I.

The resistance term in equation (1) represents the total bed resistance and is usually divided into a specific resistance defined on a mass basis (*6*) or a volume basis (*7*). Thus, we have

$$dV/d\theta = A\Delta P_f/\eta(W/A)R_w \qquad (2)$$

or

$$dV/d\theta = A\Delta P_f/\eta L_1 R_v \qquad (3)$$

where R_w and R_v are the average specific resistances of the material composing the bed on a mass and volume basis, respectively. The mass of particles in the bed at time θ is W and the length of the bed is L_1.

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Equations (2) and (3) may be integrated for conditions of constant frictional pressure drop or for constant rate of flow. In the case of compressible materials, the average specific resistance is a function of the frictional pressure drop and, hence, the interpretation of constant-rate filtrations (in which the frictional pressure drop continually increases) is considerably more complicated than the interpretation of constant pressure studies in which the average specific resistance may be readily calculated for a given value of ΔP_f. We will confine ourselves to filtrations conducted under conditions of constant frictional pressure drop.

We may write, $W = CV$, where C is the mass of particles in the filter bed per unit volume of filtrate. Substituting this value for W in equation (2), separating variables, and integrating over the limits zero to V and zero to θ gives

$$\theta = (\eta C R_w / 2A^2 \Delta P_f) V^2 \qquad (4)$$

Equation (4) may be rectified* to give a form suitable for the graphical determination of R_w by writing

$$\theta/V = BR_wV \qquad (5)$$

where

$$B = \eta C / 2A^2 \Delta P_f \qquad (6)$$

A plot of θ/V versus V will be linear and yield a value for the slope which, when divided by the experimental value of the filtration constant, B, will equal the average specific resistance, R_w.

The average specific resistance on a mass and volume basis may be related by means of equations (2) and (3).

$$R_v = C_{av.} R_w \qquad (7)$$

where

$$C_{av.} = W/AL_1$$

$C_{av.}$ is an "average" value for the concentration of fibers in the filter bed.

PERMEABILITY

There have been many investigations which have tried to relate the permeability of porous beds with certain physical properties of the material composing the bed. These static studies have been summarized by Carman (*9*) and Sullivan and Hertel (*10*).

The most successful relationship is that due originally to Kozeny (*11*), developed later by Fair and Hatch (*12*), and subsequently modified by Carman (*9*). The equation presented by Carman is usually referred to as the Kozeny-Carman equation, and has been shown to be applicable to beds of pulp fibers by Robertson and Mason (*13*) using a water permeability technique, and by Brown (*14*), using an air permeability method which takes into account the effect of slip. One form of the Kozeny-Carman equation is

$$dV/d\theta = A\Delta P_f / [\eta L k S_w^2 c^2 / (1 - ac)^3] \qquad (8)$$

where S_w is the specific surface of the material composing the bed expressed as surface area per unit mass, c is the concentration of solids in the bed, and a is the effective specific volume of the bed material. The factor k is called the Kozeny constant and equals $k_0(L_e/L)^2$, where k_0 is the shape factor and is dependent only upon the shape of the cross section of the pores, and L_e is the tortuous length the fluid traverses in passing through the bed of actual length L. Another form of the Kozeny-Carman equation is obtained if we write the length of the bed as $L = W/cA$. Thus,

$$dV/d\theta = A\Delta P_f / [\eta (W/A) k S_w^2 c / (1 - ac)^3] \qquad (9)$$

If we consider the flow rate equivalent to a driving force divided by a resistance, we may define a specific resistance on a mass basis, r_w, for a bed of *uniform porosity* from equation (9) as

$$r_w = kS_w^2 c / (1 - ac)^3 \qquad (10)$$

so that equation (9) may be written

$$dV/d\theta = A\Delta P_f / \eta (W/A) r_w \qquad (11)$$

If specific resistance is defined on a volume basis from equation (8), we have

$$r_v = kS_w^2 c^2 / (1 - ac)^3 \qquad (12)$$

and equation (8) becomes

$$dV/d\theta = A\Delta P_f / \eta L r_v \qquad (13)$$

From equations (10) and (12), $r_v = cr_w$. Specifi

Table I. Nomenclature

A	Cross-sectional area of porous bed, sq. cm. (49.5 sq. cm. for septum)
B	A constant for a given filtration, $B = \eta C/2A^2\Delta P_f$, c.g.s. units
C	Mass of fibers in a filter bed per unit volume of filtrate, g./cc.
$C_{av.}$	An average value for the concentration of fibers in a filter bed, g./cc.
K	Permeability coefficient in D'Arcy's law, $dV/d\theta = KA\Delta P_f/\eta L$, sq. cm.
L	Length of a uniform bed, cm.
L_e	Length of equivalent channels in a uniform bed (tortuous length), cm.
L_1	Length of a filter bed at time θ, cm.
M, N	Empirical constants in compressibility function, $c = Mp^N$
ΔP_f	Frictional pressure drop across a uniform bed or a filter bed, dynes/sq. cm.
R	Total resistance of a filter bed, cm.$^{-1}$
Re	Modified Reynolds number, $Re = \rho(dV/d\theta)/\eta AS_0$
R_v	Average specific resistance of a filter bed, volume basis, cm.$^{-2}$
R_w	Average specific resistance of a filter bed, mass basis, cm./g.
S_0	External surface area of fibers per unit volume of a uniform bed, sq. cm./cc.
S_v	Specific surface of fibers, volume basis, sq. cm./cc. of solids
S_w	Specific surface of fibers, mass basis, sq. cm./g. of solids
V	Filtrate volume at time θ, cc.
W	Total mass of fibers in a uniform bed or in a filter bed at time θ, g.
a	Effective specific volume of fibers, cc./g.
c	Mass of fibers per unit volume of a uniform bed, g./cc.
e	Fractional void volume of a uniform bed (void volume/bed volume), dimensionless
g	Acceleration due to gravity, 980 cm./sec.^{2}
k	Kozeny constant, $k = k_0(L_e/L)^2$, dimensionless
k_0	Shape factor in Kozeny constant, dimensionless
p	Compacting pressure, dynes/sq. cm.
r_v	Specific resistance of a uniform bed, volume basis, cm.$^{-2}$
r_w	Specific resistance of a uniform bed, mass basis, cm./g.
θ	Time of filtration, sec.
ρ	Density of filtrate, g./cc.
η	Viscosity of filtrate, poises

*The word "rectified" as used throughout this work means to arrange an equation by algebraic manipulation so that a linear relationship exists between the dependent and independent variables.

resistance is related to the permeability coefficient, K, in Darcy's equation by $r_s = 1/K$.

Using Robertson and Mason's (*13*) technique for rectifying a form of the Kozeny-Carman equation, equation (10) may be written as

$$(c/r_w)^{1/3} = (1/kS_w^2)^{1/3}(1 - ac) \qquad (14)$$

It is seen that a plot of the left-hand member of equation (14) against the pad concentration, c, will be linear if the Kozeny-Carman equation holds, and the values of the slope and intercepts can be used to calculate kS_w^2 and a.

The permeability equations presented above are valid only for conditions of viscous flow. It should be emphasized that they may be applied only to beds that are at a uniform degree of compaction—i.e., to beds in which the porosity is uniform throughout.

THE RELATIONSHIP BETWEEN FILTRATION AND PERMEABILITY

Hoffing and Lockhart (*15*) have recently presented experimental data which confirm the equivalence of specific filtration resistance and specific permeation resistance for *noncompressible* mixtures of quartz and diatomaceous earth. Ruth (*16*) found that the average specific resistance of the slightly compressible calcium carbonate, calculated from permeability data, was about 15% less than that derived from constant-pressure filtration data. Ruth felt that this difference was attributable to an aging effect on the compressibility of the calcium carbonate, and for this reason, quantitative conclusions cannot be drawn from his data. Walas (*17*) developed an empirical equation giving the specific resistance of nine compressible materials as a function of the effective particle diameter. His equation is not in agreement with the Kozeny equation. Because Walas assumed that the mean value of the porosity could be calculated by using the over-all filter cake dimensions, and that the shape factor was the same for nine different materials, the significance of his equation is doubtful.

Let us consider the possible application of the Kozeny-Carman equation to the dynamic case of a porous bed composed of compressible particles such as pulp fibers, in which the bed is formed under conditions of a constant-pressure filtration. The compression (or compacting) pressure, p, varies throughout the bed. At any given point in the bed it is equal to the frictional pressure drop past the particle at that point plus the cumulative frictional pressure drop resulting from all the particles behind it. Thus, as one goes deeper into the cake, the compressive effect increases and reaches a maximum at the septum surface ($p = \Delta P_f$). At the upstream face of the bed, the compacting pressure and frictional pressure drop are equal to zero. Expressing this situation mathematically,

$$d(\Delta P_f) = dp \qquad (15)$$

If the Kozeny-Carman equation is to be applied to such a bed it must be written for a *differential* mass of the bed, dW, of *uniform* point concentration, c, over which the differential frictional pressure drop is $d(\Delta P_f)$. Thus, for the situation at hand equation (9) becomes

$$dV/d\theta = A^2 d(\Delta P_f)/[\eta k S_w^2 c/(1 - ac)^3]dW \qquad (16)$$

This equation may be written for the whole cake by separating the variables and integrating over the cake limits since, at a given instant $dV/d\theta$ is the same at all points in the bed. Because the concentration, c, is more properly a function of compacting pressure, p, instead of frictional pressure drop, ΔP_f, we also make the substitution given in equation (15). Equation (16) then becomes

$$dV/d\theta = \frac{A \int_0^p [(1 - ac)^3/c]\, dp}{\eta(W/A)k\, S_w^2} \qquad (17)$$

The point concentration, c, must be expressed as a function of the compacting pressure, p, before the numerator can be integrated in general terms. In arriving at equation (17), the Kozeny constant, k, has been assumed to be independent of the porosity over the range involved. The Kozeny constant may be a function of porosity in the high porosity range (*10, 13, 18*).

From equations (2) and (17) average specific resistance defined on a mass basis may be expressed as

$$R_w = \frac{kS_w^2 \Delta P_f}{\int_0^p [(1 - ac)^3/c]\, dp} \qquad (18)$$

The entire preceding argument holds for equation (8) written in the differential form. In this case the average specific resistance, R_v, on a volume basis becomes

$$R_v = \frac{kS_w^2 \Delta P_f}{\int_0^p [(1 - ac)^3/c^2]\, dp} \qquad (19)$$

This relationship is nearly the same as that given for R_w. The difference is that the pad concentration, c, is squared in the denominator of the R_v porosity function, whereas it appears only to the first power for R_w. Hence, R_v is more sensitively dependent upon pad concentration than is R_w. There is no advantage to be gained in defining filtration resistance on a volume basis, but rather there is the serious disadvantage of having to determine an additional experimental value, $C_{av.}$, which in many cases is difficult to measure with ease, precision, or accuracy. Definition of filtration resistance on a mass instead of a volume basis should be a preferred procedure, at least in the case of compressible materials.

EXPERIMENTAL EQUIPMENT AND PROCEDURES

Apparatus for Dynamic and Static Studies

A single apparatus was constructed with which dynamic (constant-pressure filtrations) studies, static (permeability) studies, and compressibility measurements could be carried out. A schematic diagram of the assembled filtration and permeability tube apparatus is shown in Fig. 1.

The tube itself was made of $3^1/_8$-in. diameter Lucite with a constant-head section 6 in. in diameter at the top. Lucite flanges on the tube permitted the insertion of a screen septum which consisted of a 150-mesh screen backed by a 65-mesh screen on a perforated brass disk. The pressure drop across this septum was found to be negligible in comparison with the pressure drops used across the pulp pads in all the experiments.

A pressure tap was located in the downstream side of the tube and was connected to a water manometer

which was 2 meters long. Frictional pressure drops of from zero to 90 cm. of water could be applied across pulp pads by adjusting the height of the discharge chamber in the suction leg line. The suction leg was made up of $^7/_8$-in. diameter polystyrene flanged tubes, each section of which was about 12 in. long.

Water for use in the static and dynamic studies was obtained by the use of a constant-temperature and deaeration unit. This setup mixed filtered steam and filtered tap water by means of a $^1/_2$-in. Penberthy injector, the steam being admitted to the suction side of the injector. Filtered air was bubbled into the mixture directly after it left the injector by means of a glass nozzle mounted in the line. This air stripped the undissolved air which was liberated from the water because of the reduction in pressure and the heating of the water. The heated water was sprayed into a

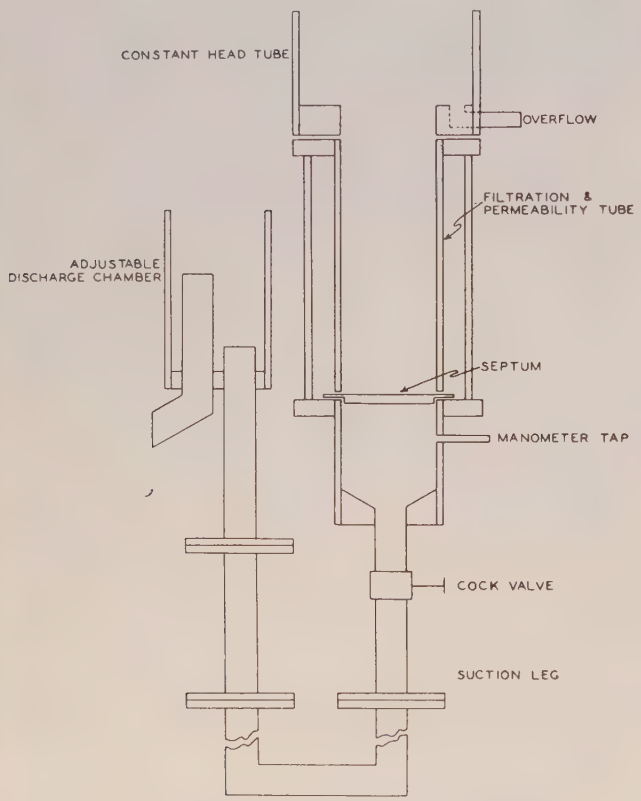

Fig. 1. Filtration and permeability apparatus

copper retention tank which was equipped with an overflow line. It was possible to have a continuous process in which filtered water, below the dissolved air saturation value (and, hence, free of air bubbles) and at a constant temperature, could be admitted to the permeability tube. The tap water contained about 100 p.p.m. of dissolved solids. To see if the presence of these ions in the make-up water had any effect on the average specific resistance, a special filtration was made with distilled water. No significant difference in the calculated filtration resistances using distilled water and tap water from the above system was observed when a prefilt concentration of 0.01% was used.

The copper tank also served as a gravity feed for pulp slurries in the filtration experiments. The procedure for carrying out a constant-pressure filtration was to pour the desired weight of pulp at 0.4% consistency into the feed tank which contained the proper amount of water at 30°C. to give a final concentration of 0.01%. The pulp suspension at 0.4% concentration had been previously soaked for 6 hr. and deaerated under water pump suction for 1 hr. The slurry in the feed tank was stirred by means of two Lightnin' mixers mounted on the tank. A constant level of slurry was maintained in the filtration tube by means of an adjustable pinch clamp on the feed line leading into the constant-head tube. The frictional pressure drop, expressed as cm. of water, was taken as the difference in the liquid levels in the constant-head tube and in the manometer, plus the manometer capillary correction. To attain a high degree of precision in taking time-volume data, the filtrate volumes, measured in graduated cylinders, were recorded by a magnetic tape recorder. After the end of a filtration, the filtrate volumes were measured as a function of time by playing back the recorded data and determining the time increments with two electric timers reading to 0.1 sec. The oven-dry pad weight was obtained by drying the wet pulp pad at 105 ± 2°C. to constant weight (±1 mg.).

In order to avoid flocculation effects it was necessary to use a combination of relatively dilute prefilt concentration and agitation of the pulp slurry in the constant-head tube. A standard prefilt concentration of 0.01% (grams of oven-dry pulp per 100 ml. of slurry) was selected after making a number of trial filtrations. At consistency values appreciably in excess of 0.01%, large fiber flocs were observed to form in the filtration tube, and the amount of agitation required to disperse the fiber flocs was so great that considerable turbulence resulted at the pad face. This turbulence disturbed the formation of the pad as a filtration proceeded. The agitation device was a variable-speed stirrer equipped with an L-shaped glass rod and mounted in the constant-head tube. Trial filtrations were made at 0.01% consistency in which the stirrer speed was varied from a maximum (a slight degree of agitation at the pad face) to a minimum (a slight settling out of fibers in the constant-head tube); no effect on the calculated value of average specific resistance was discernible. A standard stirrer speed was selected that gave rise to a slight agitation of the slurry at a point several inches above the pad level and created considerable turbulence in the constant-head tube.

At a prefilt concentration of 0.01%, the initial filtration flow rates were so high that it was necessary to open the cock valve gradually at the beginning of a filtration in order to maintain a constant liquid level in the constant-head tube. Thus, an appreciable time interval was required before the frictional pressure drop across the pulp pad reached the desired value when the cock valve was completely open. Neglect of this initial variation in ΔP_f and R_w in the integration of a filtration rate equation—e.g., equation (2)—would serve to make a portion of the data taken at constant values of these factors unreliable for the calculation of average specific resistance. When allowance for an initial variation in ΔP_f and R_w is made in the integration of equation (2), it can be shown that

$$(\theta - \theta_1)/(V - V_1) = (\eta C R_w/2A^2\Delta P_f)(V + V_1) = BR_w(V + V_1) \quad (20)$$

where the values of θ_1 and V_1 are those that correspond to reaching an equilibrium value of ΔP_f. The average specific resistance on a mass basis (R_w) was determined from the slope of a $(\theta - \theta_1)/(V - V_1)$ versus $(V + V_1)$ or V plot and the experimental value of the filtration constant (B). The mass of fibers in the pulp pad per unit volume of filtrate (C) was calculated from a knowledge of the oven-dry pad weight and the equivalent filtrate volume.

Wet pad compressibility measurements were taken over a compacting pressure range of 10 to 100 grams per sq. cm., using a screen piston similar in design to the septum. The permeable piston was provided with a sleeve about 3 in. long and $^1/_{64}$ in. thick. The outside surface of the sleeve was carefully machined and polished so that, when it was in position in the permeability tube, frictional forces between the tube and piston walls were negligible. The compressibility determinations were carried out on the pads which were formed from the filtrations at a frictional pressure drop of 90 cm. of water, since these runs had the thickest pads that were possible to be formed from a prefilt concentration of 0.01%. The pads were allowed to expand overnight following the filtrations, and then the screen piston was lowered gently onto the pad by means of an adjusting nut arrangement. This adjusting nut was screwed on a threaded portion of a piston rod which was attached to the permeable piston. The base of the nut rested on the center of a brass plate fitted on the top of the constant-head tube. Cylindrical weights with center holes were placed on the piston rod above the adjusting nut to provide the compressive force. When the piston movement came to equilibrium, the thickness of the pad was measured with a cathetometer. The data thus obtained were used to calculate the pad concentration (c) as an empirical function of the compacting pressure (p). Compacting pressure values were calculated from the known loads on the piston rod and the weight of the piston assembly (corrected for water displacement).

The screen piston was also used in the static studies to compress pulp pads to desired concentration values. The adjusting nut was used to fix the vertical position of the permeable piston and prevent continued compression of the pulp pad during flow rate measurements. In general, the procedures used by Robertson and Mason (*13*) were followed in the studies with preformed beds. Because of a decay in permeability which was found in the filtration studies on a beaten pulp, it was necessary to form beaten pulp pads for static studies from slurries at 0.4% consistency. Unbeaten pulp pads were formed at 0.05% concentration with no decay in permeability in evidence. While forming the pads, it was necessary to provide manual stirring as well as stirring in the constant-head tube to prevent gross flocculation near the pad face. These stirring operations were found to be quite critical, and considerable practice was required before homogeneous pads could be formed. Flow rate, pressure drop, water temperature, and pad thickness were measured at different values of increasing pad concentration. The data were used to calculate the product of the Kozeny constant and the square of the specific surface (kS_w^2) and the effective specific volume (a) by the application of the rectified form of the Kozeny-Carman equation given by equation (14). No flow reversals were used in any of the static studies since, in all cases, the total volume of water passed through the pads was small enough not to give any decay in permeability.

The bulk of the experimental work was done using an unbeaten pulp (880 ml. S.-R.) and a moderately beaten pulp (620 ml. S.-R.). These pulps were prepared from a batch of West Coast coniferous bleached sulphite air-dry laps and were refined in a laboratory Valley beater. The unbeaten stock was slushed for 5 min. in the beater with no bedplate load. The pulps, at a moisture content of about 70%, were stored in sealed bottles at 8°C. in the dark prior to their use in the experimental work.

EXPERIMENTAL RESULTS—THE CONCEPT OF FILTRATION RESISTANCE

Constant-Pressure Filtrations

The results of the constant-pressure filtrations are given in Table II. An example of a rectified filtration plot is shown in Fig. 2 and is representative of the

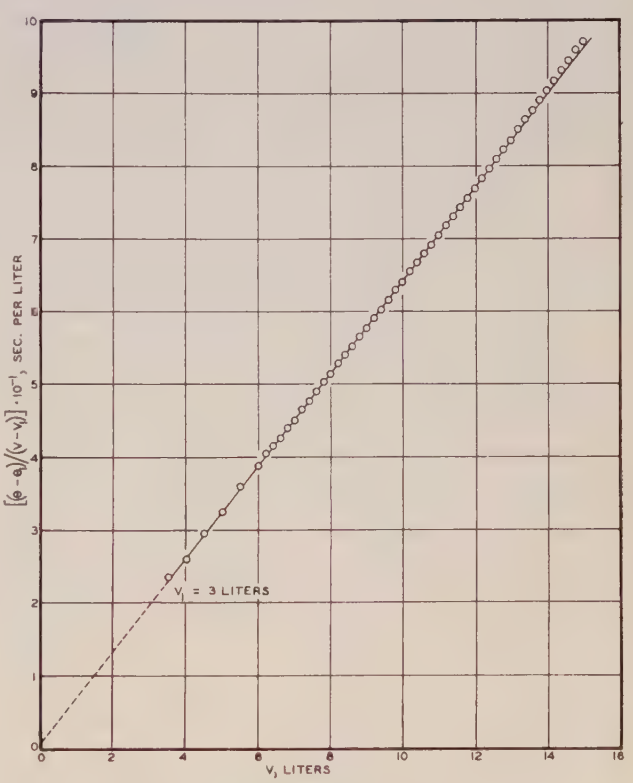

Fig. 2. Beaten pulp filtration at constant pressure of 10 cm. of water, concentration of 0.01%, at 30°C.

precision that was attained in taking filtration data. The unbeaten pulps had a constant value of average specific resistance over a large volume range, but all the beaten pulp filtrations showed increasing average specific resistance after the run had proceeded for a considerable length of time. This was indicated by an increasing slope in the rectified filtration curves. The fact that the curves for the unbeaten pulp were linear over a volume range up to 78 liters, whereas the plots for the beaten pulp showed curvature for filtrate volumes in excess of 10 to 14 liters, was regarded as strong,

but indirect, experimental evidence that the increase in filtration resistance was due to the partial movement of fines and fiber debris in the pulp pad with continued flow. A sufficient number of experimental points were available in all the beaten pulp filtrations so that a determination of slope could be made over a range where no increase in filtration resistance occurred. The data in Table II show that the filtration resistance of compressible pulp pads is a strong function of the frictional pressure drop across the pad.

Permeability Studies

The calculated results from the permeability determinations using the unbeaten and moderately beaten pulps are given in Table III. The graphical data for the rectified Kozeny-Carman equation for one of the studies are shown in Fig. 3 as being typical of all the static runs in regard to the deviation of the experimental points from the linear relationship predicted by equation (14). To avoid personal judgment in determining the slope and intercept by graphical inspection, a "method of averages" was used (*19*).

The values of the specific surface and effective

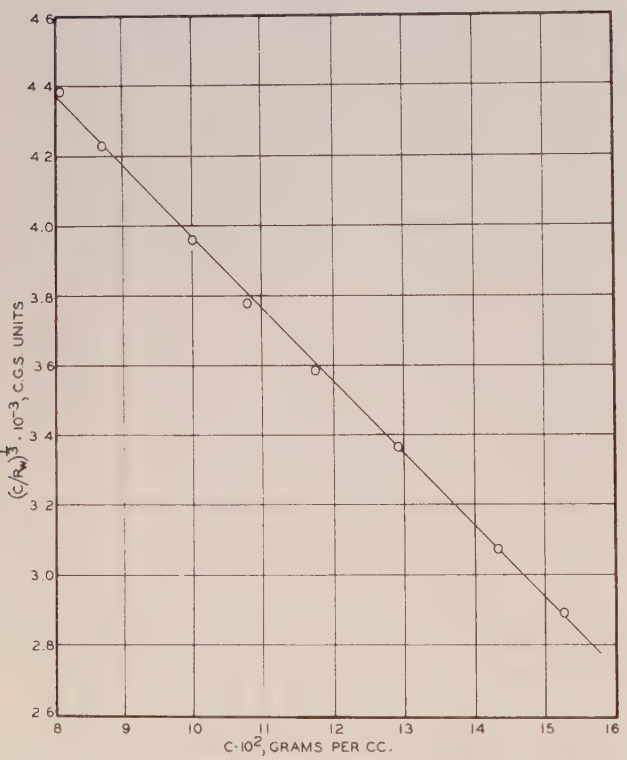

Fig. 3. Rectified Kozeny-Carman equation plot

specific volume obtained for the two pulps were of the same order of magnitude as those reported by Robertson and Mason (*13*) for similar bleached sulphite pulps using a water permeability technique. These authors have pointed out that the effective specific volumes found for wood pulps represent an abnormally high degree of swelling, but that the effective specific volume represents the hydrodynamic volume per unit mass of material—i.e., the volume denied to the flowing liquid. A portion of the abnormally high a values for pulps may be attributed to the action of fibrils which might immobilize a portion of the liquid and thus contribute to the effective volume.

Since the pulp used in this study was from the same source as that used by Brown (*14*) in his air permeability work, a comparison of the specific surface values obtained by the two methods should be of interest. Such a comparison should be done with specific surface defined on a volume basis (surface area per unit volume of solids), because the comparison is between values obtained in the water-swollen state and in the oven-dry state. The relationship involved is $S_v = S_w/a$, where S_v is the specific surface expressed as sq. cm. per cc. of solids. The water permeability and air permeability values, together with the values determined by the silvering method (*20*), are given in Table III. It seems improbable that such a large difference in specific surface, S_v, shown in Table III for the beaten pulps could be accounted for by a difference in beating techniques or by a variability in raw material. However, a possible explanation lies in the fact that Brown's pulp was prepared from very thin handsheets (0.4 gram per sheet) formed in the British sheet mold. Undoubtedly there was an appreciable loss of fines in this operation, and it is known that, although the fines may be present as a comparatively small weight fraction of the total pulp, a considerable part of the total surface area is represented by this very fine material (*20*). For example, Keeney (*21*) has found a specific surface value (determined by silvering technique) of 34,000 sq. cm. per gram for a semichemical pulp with a S.-R. freeness of 630 ml. He determined the specific surface for the same pulp after forming it into a thin handsheet (0.5 gram per sheet) in a British sheet mold, and found the specific surface had decreased to 15,600 sq. cm. per gram.

Strictly speaking, a comparison between specific surfaces of pulp fibers on a volume basis should take into account the fact that the surface area of the fibers does not change in the same proportion as does the volume of the fibers in going from the water-swollen state to the oven-dry state. Rough approximations made from the fiber dimension data of Keeney (*21*) indicated that this correction is of the order of 10 to 15%—i.e., the values of S_v in the water-swollen state should be 10 to 15% higher than those shown in Table III in order to justifiably compare them with values obtained in the oven-dry state. It appears, then, that the specific surface of fibers as measured by an air permeability technique is significantly lower than the value obtained by a water permeability method.

The silvering technique is carried out on fibers in the water-swollen state, and excellent agreement is shown between the S_w values for the unbeaten pulp used in this study. However, the water permeability technique gives a much higher specific surface value for the beaten pulp than does the silvering method. Browning (*20*) and Mason (*22*) have commented on the tendency for fines in some beaten pulps to lead to experimental difficulties in the silvering method that yield spuriously low specific surface values.

Compressibility Measurements

Wet pulp pad concentration values as a function of compacting pressure in the range of 10 to 100 grams per

sq. cm. could be represented with good precision by the empirical relationship

$$c = Mp^N \qquad (21)$$

where M and N are constants. This type of equation has been found by Campbell (*23*) for a kraft and a groundwood pulp.

occasioned by beating would tend to make a beaten pulp more compressible than an unbeaten pulp. However, there might have been compensating factors such as the shortening of fiber elements in beating that served to counterbalance changes in the fibers that would lead to increased compressibility. Campbell (*23*) also found that the compressibility constants for a kraft pulp were apparently unaffected by beating.

Table II. Average Specific Filtration Resistance

ΔPf, pg cm. water	ΔPf × 10⁻³, dynes sq. cm.	Av.[a] experimental Rw × 10⁻⁸, cm./g.	Av. deviation of experimental Rw from the mean, %	Theoretical Rw × 10⁻⁸, cm./g.	Deviation of theoretical Rw from experimental value, %	Minimum bed porosity, e
			Beaten Pulp[b]			
1	0.976	1.28	1.3	1.54	20.1	0.867
10	9.76	4.12	2.9	4.34	5.3	0.739
30	29.3	7.90	0.6	8.02	1.5	0.632
50	48.8	10.82	1.7	11.10	3.0	0.567
70	68.3	13.36	1.7	14.03	5.0	0.517
90	87.8	16.55	0.4	16.85	1.8	0.477
			Av. 1.6		Av. 6.1	
			Unbeaten Pulp[c]			
1	0.976	0.120	.....	0.133	10.8	0.913
10	9.76	0.301	.....	0.325	8.0	0.830
30	29.3	0.519	.....	0.543	4.6	0.761
50	48.8	0.671	.....	0.706	5.1	0.718
70	68.3	0.809	.....	0.847	4.7	0.686
90	87.8	0.951	.....	0.980	3.1	0.660
					Av. 6.0	

[a] The average of duplicate determinations for the beaten pulp, and the results of one constant-pressure filtration for the unbeaten pulp.
[b] Schopper-Riegler freeness, 880 ml.
[c] Schopper-Riegler freeness, 620 ml.

The compressibility constants are given in Table IV. There appeared to be no significant difference in the empirical compressibility for the unbeaten and beaten pulps and, hence, the average values of the constants were used in equation (*21*) to calculate concentration values from 0 to 90 grams per sq. cm.

When a wet pulp pad is compressed, it is not only the fibrous portion of the pad that resists the compacting force but also any water that is absorbed by the fibers and any water immobilized by fibrils. Hence, in comparing the compressibility functions of different wet pulp pads, it would be more fundamental to express the

Table III. Specific Surface and Effective Specific Volume of Bleached Sulphite Pulps

Pulp freeness, ml. S.-R.	kSw² × 10⁻⁸, c.g.s. units	Sw, sq. cm./g.	a, cc./g.	Sv, sq. cm./cc.	Silvering method,[b] Sw, sq. cm./g.	Sw, sq. cm./g. From filtration data[d]	a, cc./g. From filtration data[d]
			This Study[a] (Water Permeability)				
880	4.345	8,860	2.21	4000	8,700	8,330	2.43
620	47.15	29,200	3.40	8590	14,400	29,200	3.41
			Brown's Values[c] (Air Permeability)				
850	...	3,930	1.11	3540	9,300	....	..
610	...	4,920	1.39	3540	10,200	....	..

[a] Average of two determinations for 880 ml. S.-R. pulp and four determinations for 620 ml. pulp. Specific surfaces based on a value of 5.55 for the Kozeny constant (*13, 24*).
[b] Determinations made by the Analytical Department, The Institute of Paper Chemistry.
[c] Converted for a value of the Kozeny constant of 5.55 instead of 6.0 as used by Brown (*14*).
[d] Calculated from average specific filtration resistance values at 10 and 50 cm. of water pressure drop.

in future work. The fact that the compressibility constants M and N were apparently unaffected by beating seems somewhat surprising, since one might expect that the weakening of the fiber structure and fibrillation

Table IV. Compressibility constants

Pulp freeness, S.-R. ml.	Test	M	N
880	..	0.00421	0.315
620	A	0.00400	0.321
	B	0.00412	0.318
	Av.	0.00411	0.318

pad concentration in terms of the solid fraction, ac, instead of the pad concentration, c. Using this concept of compressibility, equation (*21*) becomes $ac = aMp^N$. Since the effective specific volume is 2.21 for the unbeaten pulp and 3.40 for the beaten pulp, the latter pulp can be considered the more compressible by the ratio of the two a values.

Carman (*9*) defined the Reynolds number (Re) for beds of porous materials as being

$$Re = \rho(dV/d\theta)/A\eta S_0$$

where S_0 is the external surface area of material per

unit volume of bed. The maximum value calculated for *Re* at any *point* in the filter beds was below the value given by Carman (*Re* = 2) as the maximum for streamline flow.

Calculation of Filtration Resistance from an Integrated Kozeny-Carman Equation

The average specific resistance has been defined on a mass basis by integrating the differential form of the Kozeny-Carman equation to arrive at equation (18).

A theoretical expression for the average specific resistance as a function of frictional pressure drop may be obtained by expressing the pad concentration, c, as a function of compacting pressure, p, using equation (21). Integrating equation (18) and making the substitution $p = \Delta P_f$, gives

$$R_w = \frac{kS_w^2}{\frac{1}{(M\Delta P_f^N)(1-N)} - 3a + \frac{3a^2(M\Delta P_f^N)}{(1+N)} - \frac{a^3(M\Delta P_f^N)^2}{(1+2N)}} \qquad (22)$$

Equation (22) may be used to calculate a theoretical average specific resistance as a function of the frictional pressure drop in a constant-pressure filtration from a knowledge of the physical properties of the material composing the bed. Using the previously determined

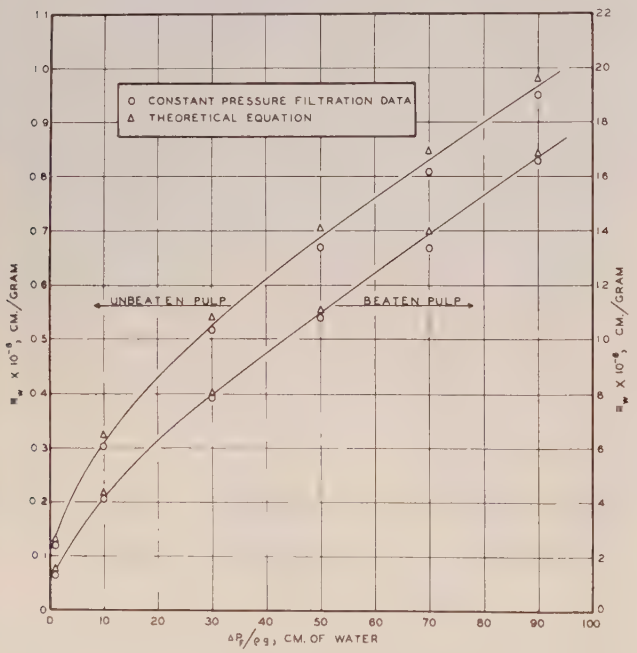

Fig. 4. Filtration resistance as a function of frictional pressure drop

values of kS_w^2, a, and M and N, the results of such calculations are given in Table II. Theoretical and observed values of filtration resistance are shown as a function of frictional pressure drop in Fig. 4.

The average deviation of all the theoretical values of R_w from the experimental values was 6%. Inspection of Table II shows that this average, especially in the case of the beaten pulp, was unduly influenced by the deviation for the filtrations at 1 cm. of water frictional pressure drop. The porosities for these filtrations were in the high range of void fractions of from 0.9 to unity where the Kozeny constant might have been variable (*10, 13, 18*). Also, the precision of the low frictional pressure drop value of 1 cm. of water was probably not greater than 10%, since these readings were made with a possible error of ±1 mm. of water. In any event, the data represented in Table II are regarded as substantial experimental proof that the filtration resistance of cellulose fibers may be expressed in terms of the filtering pressure and the properties of the fibers composing the filter bed.

Equation (18) or (22) defines the nature of the curve obtained by plotting average specific resistance against frictional pressure drop (Fig. 4) in constant-pressure filtrations over a range of pressure drops in which a definite compressibility function exists. This curve must be one with a continually decreasing slope, although it may appear to be linear over a small range of frictional pressure drop. This fact is not in agreement with the parabolic curve of increasing slope obtained by Collicutt (*25*) in his constant-pressure filtrations of groundwood pulps. However, as Collicutt pointed out, his work was complicated by the problem of agitation in the relatively high prefilt concentration range of 0.15 to 0.3%. This flocculation effect may in part explain the difference between Collicutt's results for R_w as a function of ΔP_f, and the findings of this study.

Preformed bed studies are hindered in some instances by a decay in permeability with continued flow. In some cases, the effect of this phenomenon can be minimized by a technique of flow reversals (*13*). When a decay in permeability limits the lower range of slurry concentrations from which pads of adequate thicknesses can be formed, it often leads to flocculation effects with resulting nonuniformity of pads and spuriously high permeability values. These difficulties may be overcome by calculating specific surface and effective specific volume values from the results of two constant-pressure filtrations and a compressibility measurement. Average specific filtration resistance, defined on a mass basis, can be determined for thin pads of nonmeasurable thicknesses, through which the total volume of flow has been small enough not to give rise to a decay of permeability. The only limiting factor for prefilt concentration and flow time is that the flow must be laminar.

For example, arbitrarily taking the filtration resistances determined at frictional pressure drops of 10 and 50 cm. of water, and using the compressibility data given in Table IV, equation (22) may be written as two simultaneous equations which can be solved for the two unknowns, specific surface and effective specific volume. The values of S_w and a calculated in this manner, and shown in Table III, compare favorably with the static study results. The calculation of specific surface and effective specific volume from dynamic data may also be useful in cases where the permeability of preformed beds is too low to yield measurable volumes of flow over the necessary pad concentration range.

The Effect of Temperature and Prefilt Concentration

Four constant-pressure filtrations with the moderately beaten pulp were made at temperatures from 10 to 40°C., using a prefilt concentration of 0.01% and a frictional pressure drop of 10 cm. of water. The average deviation of the R_w values from the mean was

1.4%, and it was concluded that temperature had no effect on average specific resistance under these filtration conditions. The range of the viscosity of water in these experiments was from 0.7 to 1.3 cp.

Constant-pressure filtrations at 10 cm. of water frictional pressure drop and at prefilt concentrations of 0.05 and 0.10% were made with the beaten pulp, and at 90 cm. of water and 0.05% concentration with the unbeaten pulp. At 0.05% concentration, large fiber flocs (about 1 to 3 cm. in diameter) were observed to form during the filtration. At 0.10% consistency the size of the flocs could not be estimated, but fibers were observed to form into irregularly shaped masses several inches in diameter during the filtration. To prevent extreme settling of the fibers in the filtration tube and to minimize the flocculation of fibers at these higher consistencies, it was necessary to increase the speed of the stirrer over that used in the experiments at the standard prefilt concentration of 0.01%. This resulted in some unavoidable turbulence near the pad face which was quite severe in the 0.10% concentration run.

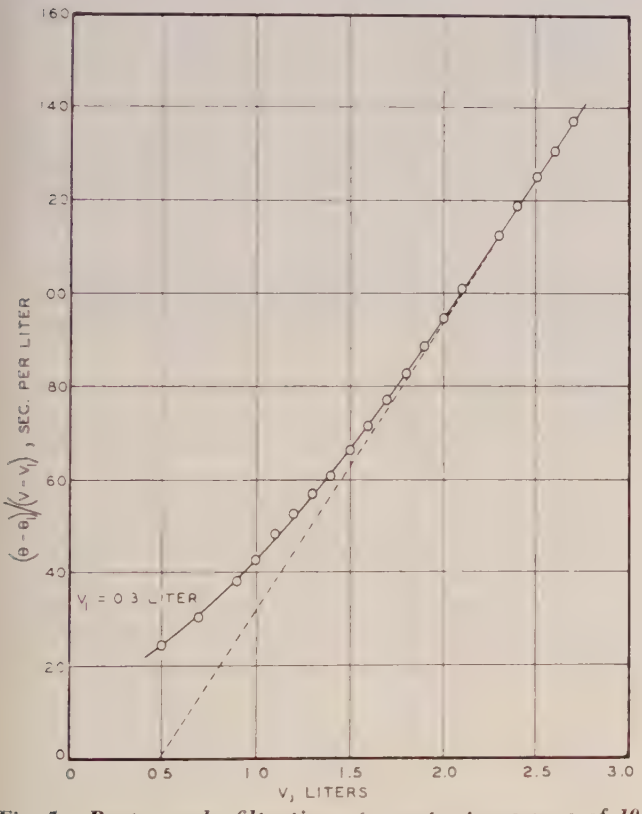

Fig. 5. Beaten pulp filtration at constant pressure of 10 cm. of water, concentration of 0.10%, at 30°C.

The rectified plot for the 0.10% filtration is given in Fig. 5. The plot shows considerable curvature for an appreciable part of the filtration. A similar type of curvature, but not as great as in Fig. 5, was found for the 0.05% run with the beaten pulp. It was noted in these two filtrations that fines were visible in the filtrate over a major portion of the runs where curvature was shown in the plots. The increasing slopes appeared to approach linearity in the latter stages of the filtrations, but slope values obtained in these ranges gave average specific resistances which were from 15 to 25% less than those obtained with the standard prefilt concentration of 0.01%. The unbeaten pulp filtration at 0.05% was linear over the entire volume range, but the filtration resistance was about 25% smaller than that at 0.01% consistency. No fines were visible in the filtrate for this run.

Because of the inability to obtain homogeneous and reproducible pads at prefilt concentrations appreciably in excess of 0.01% and because of the loss of fines from a beaten pulp over a major portion of the filtrations, it is extremely doubtful that values for average specific resistance at these higher consistencies have any fundamental mathematical basis.

Aging Effect

The effect of pulp age on average specific resistance is shown in Table V. Of the factors upon which filtration resistance is dependent, it is unlikely that either the Kozeny constant or the specific surface would be altered under the conditions at which the pulp was stored (airtight container at 8°C. in the dark with no visible evidence of bacterial action). The pulp sample had a moisture content of 74%, and it might have been possible for swelling to have taken place during time of storage. However, increased swelling would be reflected in an increased value of effective specific volume which would result in an increasing filtration resistance. This effect is opposite to that which was observed.

Table V. Effect of Pulp Age on Filtration Resistance[a]

Pulp age,[b] *days*	$R_w \times 10^{-8}$, *cm./g.*	$C_{av.}$, *g./cc.*
4	4.24	0.0258
23	4.00	0.0232
34	3.87	0.0222

[a] R_w determined at $\Delta P_f/\rho g$ = 10 cm. of water, C = 0.01%, t = 30°C.
[b] Zero time taken as the day the pulp was refined in the beater.

It can be shown from a consideration of equations (7), (18), and (19) that the average pad concentration is equal to the ratio of the porosity functions for R_w and R_v, respectively. Thus, relatively small changes in effective specific volume tend to be counterbalanced in their effect on C_{av}. However, comparatively small changes in pad compressibility should have an appreciable effect on C_{av}.—e.g., a slight decrease in pad concentration (c) at a given value of compacting pressure (p) would lead to a lower value of C_{av}. Also, a decrease in pad compressibility would give lower values of average specific resistance. The data in Table V support these conclusions, and apparently it was the wet flexibility of the fibers that had been altered—wet flexibility had decreased with time of storage.

Freeness and Filtration Resistance

A comparison of freeness and average specific resistance is shown in Table VI. The data show that the freeness test is not a measure of the filtration resistance as it has been defined in this study. This is not surprising, since the freeness tester operates under conditions of falling frictional pressure drop and at a relatively high prefilt concentration (0.2% for the Schopper-Riegler tester). The work done in measuring pad concentrations indicated that pulp pads formed in filtrations would not spring back completely to their true compaction value at a lower pressure. Therefore,

interpretation of any data obtained under conditions of varying frictional pressure drop may be quite difficult. The constant-pressure filtrations at a consistency of 0.1% showed that pulp pads so formed could not be assigned a definite value of average specific resistance because of a loss of fines and flocculation effects. Freeness and drainage testers which operate in this consistency range would be subject to the influence of these factors.

Table VI. Comparison of Freeness and Filtration Resistance

S.-R. freeness, ml.	*Average specific resistance,*[a] $R_w \times 10^{-9}$, *cm./g.*
880	0.301
620	4.12
175	70.9

[a] At $\Delta P_f/\rho g = 10.0$ cm. of water.

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A Method of Laboratory Evaluation of Chemicals as Potential Slimicides

SYLVAN I. COHEN and MERCINE KALM

In the initial screening of chemicals as potential slimicides frequent variability of antiseptic data has been encountered from test to test. Using standard methods, it is often impossible in our laboratory to distinguish between such variability and any intrinsic toxicity associated with the chemical structure of similar compounds. This was found to be especially true for mercurials. To reduce this variation, the standard Petri plate method of Appling and McCoy was modified to improve the accuracy of several steps by (1) standardization of inoculum to 1 million organisms per ml., (2) thorough mixing of chemical and melted agar in test tubes before pouring plates, (3) addition of inoculum to cooled, melted agar instead of surface streaking, (4) extremely accurate dilutions of the chemical. In spite of these modifications, no significant improvement occurred in accuracy and reproducibility. This suggested that the type of medium is an important factor. A synthetic liquid medium was adopted and used in a test tube technique. One milliliter of a dilution-series of the chemical is added to 9 ml. of the medium, followed by 0.1 ml. of inoculum. The tubes are agitated by hand at fixed intervals or continuously on a shaketable. After 24 and 48 hr. of incubation, turbidimetric measurements are made yielding germistatic data. Information about germicidal action and killing-time are obtained by combining the chemical dilutions with the inoculum for arbitrary time intervals before loop transfers are made to media tubes. The latter procedure also permits evaluation of chemicals that cannot be added directly to the synthetic medium. The above technique has proved reproducible and accurate at least to 7.7% with compounds that could not be assayed with the plate method. Three bacteria and one fungus were employed satisfactorily as screening organisms to date. The new method offers the possibility of developing dosage-response data for interpreting the dynamic relations between microorganisms and antiseptics.

In the past 10 years our laboratory has evaluated chemicals for the paper industry, employing the published methods of the Institute of Paper Chemistry (*1*, *2*). The principal initial screening test is used to determine the bacteriostatic and fungistatic effectiveness of compounds by incorporating them in a nutrient agar at several concentrations, then determining the inhibitory end point or concentration (Petri plate method). While this technique usually permits the assignment of a chemical to a general category of effec-

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tiveness, it has been observed over a period of years that the inhibitory concentration of certain chemicals varies from test to test. This is especially true for organomercurial compounds which were being studied, even in the hands of three technicians. Often in comparing similar chemicals of this group, the test-to-test variation is greater than the intrinsic difference between the chemicals, so that no conclusive deductions can be made regarding the influence of chemical structure upon toxicity.

Accordingly, initial efforts were made to refine the basic techniques in order to improve the accuracy of the Appling and McCoy method (*2*). When such modifications still did not yield reproducible data for these mercurials, a new procedure was sought using a synthetic liquid medium. This paper contains a preliminary report of studies with a new method that has reduced such variation.

EXPERIMENTAL STUDIES

Tests with Standard Agar-Plate Method

Early in 1951 our laboratory began to compare a series of five water-solubilized formulations of phenyl mercury compounds. For these studies the solutions were standardized to contain equivalent amounts of the phenyl mercury group. Evaluation was then attemped using the agar-plate method of Appling and McCoy (*2*) which was standard practice in our laboratory. All the formulations were tested simultaneously usually employing two species of test organism. The first range in concentration of disinfectant consisted of 3 to 4 dilutions above and below an estimate previously determined or in the literature. Thereafter, it was planned to narrow down the inhibitory concentration to within 15% gradations. Table I contains a summary of these results for two selected disinfectants assayed against five bacteria, a yeast, and a mold. The data presented are typical of other tests and for similar chemicals, showing difficulty to obtain the same inhibitory concentration upon retest. At first, there appeared to be differences in toxicity between P305 and P200 when tested against *B. subtilis*, *F. aquatile*, *A. aerogenes*, and *Torula sp.* However, the variations occurring in subsequent tests usually concealed such differences.

Table I. Results with Standard Appling and McCoy Method Showing Unreproducibility of Results, Feb. 6, 1951

	Growth after 48 hr. incubation[a]					
	P305[b]			P200[c]		
	I	*II*	*III*	*I*	*II*	*III*
			Bacillus subtilis			
1:300,000	..	+4	+4	..	..	+4
1:250,000	..	+4	+4	..	+4	+4
1:200,000	0	+4	+4	+1	+4	+4
1:175,000	0	..	+2	0	+4	+4
1:150,000	0	..	+1	0	..	+3
			Flavobacterium aquatile			
1:1,000,000	..	+4	+4	..	..	+4
1:900,000	..	+4	..	..	+4	..
1:800,000	0	+3	+4	+2	+4	+4
1:666,666	0	..	+4	0	+4	+4
1:500,000	0	..	+4	0	..	+4
1:400,000	..	..	+2	..	..	+2
			Aerobacter Aerogenes			
1:133,000	..	+4	..	..	..	..
1:100,000	..	+4	..	..	..	..
1:80,000	0	+4	..	+3	..	..
1:60,000	0	..	..	+1	..	+4
1:50,000	..	..	..	..	..	+4
1:40,000	0	..	..	0	..	+4
			Monilia sitophila			
1:40,000	+3	..	..	+3	..	..
1:30,000	+	..	..	+2	..	..
1:20,000	+	0	..	+2	0	..
1:13,000	..	0	..	..	0	..
1:10,000	..	0	..	..	0	..
1:8,000	..	0	..	..	0	..
			Pseudomonas fluorescens			
1:50,000	..	+4	..	..	+4	..
1:40,000	..	+4	..	..	+4	..
1:30,000	0	+3	..	0	+3	..
1:20,000	0	+2	..	0	+3	..
1:10,000	0	..	..	0	..	..
			Alcaligenes viscosus			
1:50,000	+4	..	..	+4	..	..
1:40,000	+4	..	..	+4	..	..
1:30,000	+4	..	..	+4	..	..
1:20,000	+4	0	..	+4	0	..
1:13,333	..	0	..	..	0	..
1:10,000	..	0	..	..	0	..
			Torula sp.			
1:133,333	..	+	..	..	..	..
1:100,000	..	0	..	..	0	..
1:80,000	0	0	..	+2	0	..
1:66,000	0	..	..	0	0	..
1:50,000	0	..	..	0	..	..

[a] Incubation for Monilia was 7 days.
[b] P305 is a short designation for phenyl mercuri monoethanolammonium acetate.
[c] P200 refers to phenyl mercuri ammonium acetate.

Tests with Modified Agar-Plate Method

In an attempt to reduce such variation the following modifications were introduced into the procedure of the agar-plate technique:

1. Standardization of the inoculum to 1,000,000 organisms per ml. Using the published technique, the concentration was determined to vary from about 20 million to 175 million organisms per ml. from different slants.

2. Extremely accurate dilutions of the chemical. Instead of preparing one stock solution of the chemical having 0.25 or 0.025% concentration and adding 0.1 to 0.5-ml. aliquots to sufficient agar to make 10.0 ml., a series of dilutions was carefully prepared so that exactly 1.0-ml. portions could be added to 9.0 ml. of nutrient agar. This reduced the chance of error in final concentration caused by the addition of 0.1-ml. increments of disinfectant.

3. Thorough mixing of chemical and agar. Instead of relying upon rotation of the Petri dish containing melted agar and chemical, the 1 ml. of chemical was added to a test tube of 9 ml. of melted agar and then agitated thoroughly in a water bath before pouring the plate.

4. Incorporation of inoculum into the cooled, melted agar instead of streaking it on the surface of the solidified agar containing the chemical. This improved the opportunity for the test microorganism to contact the homogeneous agar-antiseptic medium.

The results obtained using this procedure are shown in Table II. Previous data had suggested the inhibiting concentration of P305 against *B. subtilis* to be about 1:200,000. For three consecutive tests, the technique appeared promising, yielding a bacteriostatic

Table II. Results with the More Accurate Modified Appling and McCoy Method. *Bacillus subtilis-P305*[a] May, 1951

	Growth after 48 hr.			
	5/14	5/15	5/16	5/22
1:2,000,000	..	..	+4	..
1:1,500,000	..	..	+4	..
1:1,000,000	..	..	+4	..
1:850,000	..	..	..	+4
1:800,000	..	..	+4	+4
1:750,000	..	..	..	+4
1:700,000	..	..	..	+4
1:650,000	..	..	..	+4
1:600,000	..	0	0	+4
1:550,000	..	..	..	+4
1:500,000	..	0	..	..
1:400,000	..	0	..	..
1:300,000	0	0	..	..
1:250,000	0	0	..	..
1:200,000	0	..	..	..
1:150,000	0	..	..	..
1:100,000	0	..	..	..
1:50,000	0	..	..	..

[a] P305: phenyl mercuri monoethanolammonium acetate.

end point between 1:600,000 and 1:800,000. However, on trying to narrow down this point, growth occurred at all concentrations between 1:550,000 and 1:850,000.

This suggested that perhaps the susceptibility of the bacterium might be an important factor since *B. subtilis* forms spores. Four mercurial solutions were tested simultaneously according to the previous method, except that the inoculum was either from a 24-hr.-old slant or from one which had been transferred three times every 24 hr. Table III shows that the type of inoculum did not alter the bacteriostatic property of any of the disinfectants.

Table IV is a summary of our efforts to compare four phenyl mercury compounds in a series of agar-plate tests against five species of bacteria commonly associated with slime in the paper mill. As in the previous comparative study, all solutions were standardized before dilution to contain equivalent amounts of the phenyl mercury group. Note the wide increments in chemical concentrations used so that inhibition at any one concentration should be significant. In general all formulations performed about equally except P302 which usually was less effective than the rest. Of the four phenyl mercurials P200 proved equal or superior to all the others except against Pseudomonas. These results suggested the importance of the species of microorganism in evaluating several disinfectants. Based on equal phenyl mercury content, these data indicated that certain molecular structures influenced the toxicity of a compound.

Comparing Tables III and IV, it is interesting to note the unreproducibility of inhibiting concentration against the same organism, *B. subtilis*. Table III shows P305 effective at 1:225,000, while P200 gave total inhibition at 1:75,000. In Table IV however, the effectiveness was apparently reversed, with P200 inhibiting at about 1:100,000, and no end point for P305 even at 1:75,000. Thus, it was soon apparent that even the modified agar-plate method could only yield relative evaluations which might change radically from test to test.

Therefore, other methods were sought to reduce variability. All the previous work indicated that the nutrient agar was an important factor which had not been varied in the procedure. The literature contained two pertinent statements about the effect of agar upon mercurial antiseptics. Appling and Shema (*1*) reported certain disinfectants which they studied might be bound to components of nutrient agar when added to such medium. Miller and Rose (*3*), however, found that agar alone did not alter the effectiveness of mercuric chloride or three other organic mercury antiseptics when assayed against *Staphylococcus aureus* in beef extract tested as a broth or an agar. To eliminate the role of agar or other undetermined components of media like beef extract, a synthetic medium was selected for further studies.

Tests with Synthetic Liquid Medium

Materials and Methods. The writers are indebted to S. H. Hutner of the Haskins Laboratories for suggesting the following medium based upon his vast experience with the physiology of microorganisms. For our purposes, only slight modifications were necessary to utilize this medium for the test organisms.

Potassium citrate monohydrate	0.06%
Magnesium sulphate septahydrate	0.02%
Potassium dihydrogen phosphate	0.02%
Monosodium glutamate	0.4%
Mannitol	0.5%
l-Arginine hydrochloride	0.02%
dl-Alanine	0.05%
Ca (CO_3 in HCl)	0.5 mg. %
Fe (as $FeSO_4 \cdot 7H_2O$)	0.4 mg. %
Mn (as $MnSO_4 \cdot H_2O$)	0.6 mg. %
Zn (as $ZnSO_4 \cdot 7H_2O$)	0.4 mg. %

The ingredients are added to distilled water and the pH is adjusted before sterilization. For bacteria, the pH is adjusted to 6.6 to 6.8 if any modification is necessary. For fungi, the pH is adjusted to 5.5, and 3 to 4% glucose may be substituted for the mannitol. The medium is always clear and usually colorless when prepared, developing a faint lemon color after autoclaving. When glucose is used as a carbohydrate, an amber color develops. If any precipitate forms, the potassium citrate is increased to 0.07%.

This liquid medium is prepared and autoclaved in stock flasks. At the time of use, aliquots are pipetted aseptically into sterile bacteriological test tubes to avoid changes in volume caused by autoclaving. Two types of test procedures are followed with this medium:

1. Bacteriostatic test. This technique is used if the antiseptic dilutions are compatible with the medium, and if inhibitory data are desired. Exactly 9.0 ml. of medium are added to each sterile tube of a dilution series. Meanwhile, the chemical to be assayed is prepared as a series of aqueous dilutions having

Table III. Effect of Age of Transfer of *Bacillus subtilis* upon Modified Appling and McCoy Agar-Plate Bacteriostatic Test, March 29, 1951

Toxicant concentrations	Growth after 48 hr.							
	P305[a]		P200[b]		P302[c]		N5DS[d]	
	S[e]	M[f]	S[e]	M[f]	S[e]	M[f]	S[e]	M[f]
1:225,000	0	0	+4	+4	+4	+4	+4	+4
1:150,000	0	0	+4	+4	+2	+4	+4	+4
1:75,000	0	0	0	0	0	0	0	0
1:10,000	0	0	0	0	0	0	0	0

[a] P305: phenyl mercuri monoethanolammonium acetate.
[b] P200: phenyl mercuri ammonium acetate.
[c] P302: phenyl di-(mercuri ammonium acetate).
[d] N5DS: phenyl mercuri triethanolammonium lactate.
[e] S = 24-hr. transfer from stock culture.
[f] M = Three 24-hr. serial transfers from stock.

nine-tenths the final concentration, so that the addition of 1.0 ml. of a dilution to 9.0 ml. of medium produces the desired concentration. A very satisfactory dilution-series for rapid initial evaluation consists of 1:1000, 1:10,000, 1:100,000, 1:500,000, and 1:1,000,000. All series are prepared in duplicate, which has proved satisfactory for our work. Duplicate controls consist only of 10 ml. of medium. Finally, all test tubes are inoculated with 0.1 ml. of a suspension of the test organism in sterile distilled water adjusted to contain about 1,000,000 organisms per ml. The test tubes are agitated thoroughly and incubated in racks at the optimum temperature for 48 hr. The racks are agitated by hand at arbitrary intervals, although it is planned to accomplish this continuously using a shake-table. Visual and turbidimetric observations are made after 24 and 48 hr.

2. Bactericidal Test. This modification is used for chemical solutions which produce a turbidity when added to the synthetic medium. It is also employed whenever bactericidal activity or killing-time is to be determined.

Ten milliliters of sterile medium are pipetted into sterile test tubes to serve as subcultures. The chemical to be evaluated is prepared separately as a series of aqueous dilutions at the final arbitrary test concentrations. Twenty-five-milliliters aliquots of each dilution-series are transferred to large sterile test tubes, to each of which is added 0.1 ml. of inoculum standardized to contain 1,000,000 organisms per ml. The inoculated chemical dilutions are agitated thoroughly. Then, after one or more arbitrary time intervals, two 4-mm. loopfuls of mixture are transferred aseptically to each subculture of medium. The inoculated subcultures are agitated thoroughly and placed in racks for incubation for 48 hr. at the optimum temperature for the test organism. Thus the potential germicide has been placed in contact with the standardized test organism, then diluted about one thousand times by loop transfer to the synthetic liquid medium. The absence of turbidity in the subcultures after 48 hr. indicates complete death of the test organism at the specific dilution and time interval. To be certain that the loopfuls of inoculum and chemical do not permit germistasis in the subcultures, all negative tubes are inoculated with one loopful of bacterial suspension and incubated an additional 48 hr. Growth appears as cloudiness; if not, the observation is discarded.

For germicidal screening, the initial dilution-series typically comprises five chemical concentrations which are mixed with the test organism for an arbitrary 2 hr; viz., 1:1,000, 1:10,000, 1:100,000, 1:500,000 and 1:1,000,000. The germicidal concentration can later be narrowed down to within 10% gradations based upon the results of the first test. Data concerning killing-time are determined at one or more effective concentrations by the usual practice of making transfers from the chemical-inoculum mixture over any range of time. One minute to eight hours has been found convenient and informative.

At the end of the incubation period for both germistatic and germicidal techniques, the test tubes are examined for growth visually and turbidimetrically. The visual observation is very approximate, being of value mostly to indicate growth or no growth. The controls are assigned a rating of 4+; all other test tubes are compared with the controls and their appearances recorded as 0 through 4+. The turbidimetric reading is very precise, and is made with a Lumetron model 402E colorimeter. In preliminary work it was established that the most accurate turbidimetric measurements were attained using a Corning filter No. 511.3 of half-standard thickness (345 to 480 mmu range; 410 mmu peak). Where great accuracy is desired the incubated cultures are transferred from bacteriological test tubes to special optical tubes (cuvettes) just before readings are taken. The turbidimeter is first adjusted to 100% light transmittance using a tubeful of the sterile synthetic medium. Then readings are taken using the series of experimental test tubes.

Table IV. Attempts to Compare the Bacteriostatic Properties of Four Phenyl Mercury Compounds Using a Modified Appling and McCoy Agar-Plate Method, March 23–April 19, 1951

Organism and chemical concentrations	*Growth after 48 hr.* P305[a]	P200[b]	P302[c]	N5DS[d]
	Bacillus subtilis			
1:225,000	+4	+2	+4	+4
1:200,000	+4	+1	+4	+4
1:150,000	+4	+1	+4	+4
1:100,000	+4	0	+4	+4
1:75,000	+3	0	+4	+4
	Aerobacter aerogenes			
1:300,000	+4	+4	+4	+4
1:200,000	+4	+4	+4	+4
1:100,000	+4	+4	+4	+4
1:50,000	0	0	+2	0
1:20,000	0	0	0	0
	Escherichia coli			
1:225,000	+4	+4	+4	+4
1:150,000	+4	+4	+4	+4
1:75,000	+4	+4	+4	+4
1:10,000	0	0	0	+2
	Bacillus megatherium			
1:225,000	0	0	+4	0
1:150,000	0	0	+4	0
1:75,000	0	0	0	0
1:10,000	0	0	0	0
	Pseudomonas fluorescens			
1:225,000	+4	+3	+4	+3
1:150,000	+2	+2	+3	0
1:75,000	+1	+1	0	0
1:10,000	0	0	0	0

[a] P305: phenyl mercuri monoethanolammonium acetate.
[b] P200: phenyl mercuri ammonium acetate.
[c] P302: phenyl di-(mercuri ammonium acetate).
[d] N5DS: phenyl mercuri triethanolammonium lactate.

Table V. Results Using Synthetic Liquid Medium Method for Bacteriostasis. P305[a] versus *Aerobacter aerogenes*, June, 1951

Chemical concentrations	*Growth after 48 hr.* I	II	III
1:2,000,000	+	..	..
1:1,000,000	+	..	..
1:850,000	+	..	..
1:800,000	+	..	..
1:750,000	+	+	+
1:700,000	+	+	+
1:650,000	+	+	+
1:600,000	0	0	0
1:550,000	0	0	0
1:500,000	0	..	0

[a] P305: phenyl mercuri monoethanolammonium acetate.

Table VI. Determination of Killing Time for P200[a] Against *Aerobacter aerogenes* for Use in Bactericidal Screening Method with Synthetic Liquid Medium

Time, min.	Growth after 48 hr. 1:300,000 V.[b]	1:300,000 T.[c]	1:400,000 V.[b]	1:500,000 V.[b]	1:600,000 V.[b]	1:600,000 T.[c]
1	+3	16.8	..	..	+3	10.5
5	+3	14.2	..	..	+3	10.7
15	+3	16.0	..	..	+3	14.0
30	+1	79.0	..	..	+3	18.8
45	0	100	..	..	+3	14.8
60	0	100	+	+	+3	18.0
120	0	100	0	+	+1	66.8
240	0	100	0	0	0	100
420	0	100	0	0	0	100
1440	..	..	0	0	..	..

[a] P200: phenyl mercuri ammonium acetate.
[b] Visual rating; controls = +4.
[c] Turbidimetric reading as per cent light transmittance; controls = 10.7.

The measurements are reproducible within 1% variation.

Preliminary studies showed that the following microorganisms could be used with this technique: *Aerobacter aerogenes*, *Bacillus subtilis*, *Escherichia coli*, and *Penicillium notatum*. At this time most of the assays have been done with Aerobacter. The inoculum is grown on a Difco nutrient agar slant for 24 hr., which is then washed with sterile distilled water and made up to a volume of 100 ml. To reduce clumping of the bacteria, 0.1% Aerosol OT is added to the suspension. A sample of this bacterial suspension is then placed in the turbidimeter and the light transmittance recorded. The population of the inoculum is determined by interpolation from a calibration curve based upon previous plots of the light transmittance against plate-counts of such suspensions. The inoculum is then standardized to contain about 1,000,000 organisms per ml. by subsequent dilution. For example, a reading of 55% is equivalent to a concentration of 140,000,000 cells per ml. Such a suspension is then standardized by diluting 1 ml. up to 140 ml. with sterile distilled water.

RESULTS USING THE SYNTHETIC MEDIUM METHOD

The results obtained for one phenyl mercurial using the bacteriostatic type test are shown in Table V. Based upon agar-plate data, the inhibiting concentration of P305 appeared to be in the range of 1:50,000 to 1:80,000. (See Tables I and IV.) The first screening test, which has been omitted here for brevity, showed that the end point for P305 lay between 1:500,000 and 1:1,000,000. The end point was then narrowed down in test I to between 1:600,000 and 1:650,000. Two subsequent tests confirmed this bacteriostatic concentration and demonstrated that the technique yields reproducible results. It is interesting to compare the bacteriostatic concentrations for this slimicide using the agar-plate and synthetic medium methods. Typically the average end point with the agar-plate method is about 1:65,000; with the synthetic method, 1:600,000. Thus the new technique rates the slimicide 9.2 times more effective in the absence of nutrient agar. Similar differences were noted by Appling and Shema (*1*) in 1942 for a phenyl mercuric acetate product (Merfenel). Their Table I shows a killing concentration of 1:100,000 when the disinfectant was combined in the agar. But when the same compound was evaluated with their flask method, in which it is not in contact with the nutrient agar, a killing concentration of 1:1,000,000 was recorded in their Table II. This is a factor of 10 times greater effectiveness in the absence of nutrient agar, which agrees closely with our factor of 9.2. These findings corroborate the inactivating effect of standard nutrient agar upon phenyl mercurials and suggest an explanation for the discrepancies occurring in the agar-plate evaluations.

Table VI illustrates the use of the bactericidal test technique to obtain killing-time information for another phenyl mercury slimicide, P200. It was conducted first in order to select an arbitrary contact time for use in later studies of killing concentrations of these mercurials. Having determined the inhibiting concentration to be 1:600,000, the initial tests were made in the range of 1:300,000 to 1:600,000. The data show that none of the Aerobacter cells survived an exposure of slightly more than 2 hr. at the inhibitory concentration of 1:600,000. Increasing the disinfectant concentration in steps to 1:300,000 reduced the time required for bactericidal action to about 30 min. Based upon these results subsequent bactericidal tests were conducted in which the disinfectant remained in contact with the microorganism for at least 2 hr.

The synthetic liquid medium test procedure is also used to screen any potential disinfectant besides the mercurials which have been shown to be difficult to evaluate in agar plates When a new chemical or formulation is received for biological screening, the first property ascertained is its water solubility. If it is soluble, a 1:1000 dilution of the sample is added to the liquid medium to determine compatibility. If no precipitate develops, the initial screening comprises the bacteriostatic method over a range of concentrations

Table VII. Bactericidal Screening of a Series of Aromatic Ketone Compounds Using *Aerobacter aerogenes* and Synthetic Liquid Medium, Dec., 1951

Chemical and dilution	Test I V.[a]	Test I T.[b]	Test II V.[a]	Bactericidal concentration
		o-Hydroxy Derivative		
1:1,000	0	100	..	1:1,000
1:10,000	+4	25.0	..	
1:100,000	+2	62.0	..	
1:500,000	+4	8.0	..	
1:1,000,000	+4	8.5	..	
		p-Hydroxy		
1:1,000	0	100	..	1:1,000,000
1:10,000	0	100	..	
1:100,000	0	100	..	
1:500,000	0	100	..	
1:1,000,000	0	100	..	
		di-Hydroxy		
1:1,000	..	..	0	1:3,000
1:3,000	..	..	0	
1:5,000	..	..	+4	
1:7,000	..	..	+4	
1:10,000	..	..	+4	
1:20,000	..	..	+4	
		tri-Hydroxy		
1:10,000	..	..	0	1:25,000
1:25,000	..	..	0	
1:50,000	..	..	+4	
1:75,000	..	..	+4	
1:100,000	..	..	+4	
1:125,000	..	..	+4	

[a] Visual rating.
[b] Turbidimetric reading as per cent light transmittance.

Table VIII. Comparison of the Bacteriostatic Properties of Five Phenyl Mercury Compounds Using the Synthetic Liquid Medium Method and *Aerobacter aerogenes*, Oct., 1951

Chemical dilution	Growth after 48 hr. P200[a]		P302[b]		N5DS[c]		P305[d]		P806[e]	
	V.[f]	T.[g]	V.[f]	T.[g]	V.[f]	T.[g]	V.[f]	T.[g]	V.[f]	T.[g]
1:600,000	0	100	+3	35.5	0	100	0	100	0	100
1:700,000	+1	71.5	+3	41.5	+1	78.3	+1	87.7	0	100
1:800,000	+3	51.8	+4	31.7	+2	62.7	+3	51.8	+1	73.7
1:900,000	+4	30.5	+4	29.9	+4	26.8	+4	46.0	+4	31.0

Control = + 4; 25.9.
[a] P200: phenyl mercuri ammonium acetate.
[b] P302: phenyl di-(mercuri ammonium acetate).
[c] N5DS: phenyl mercuri triethanolammonium lactate.
[d] P305: phenyl mercuri monoethanolammonium acetate.
[e] P806: phenyl mercuri formamide.
[f] Visual rating.
[g] Turbidimetric reading as per cent light transmittance.

from 1:1,000 to 1:1,000,000. Should the chemical prove incompatible with the medium, the bactericidal technique is used in the same dilution range. Using either method, the potential disinfectant is usually compared with a reference slimicide to verify the validity of the test results. This is comparable to the role of phenol in the phenol coefficient test.

As an example of the screening of nonmercurial compounds, Table VII illustrates the value of this method for determining quickly the most effective chemical structure of a series of aromatic ketones. In this particular study, which was part of a larger evaluation program, the objective was to determine the value of the hydroxyl group and its position in the basic molecule. These data suggest that there are significant differences in bactericidal activity of the four derivatives tested, and that the *p*-hydroxy structure is the most effective. Apparently polyhydroxylation does not improve the toxicity of the molecule unless one of the entering groups is in the para position. Unfortunately, during the course of these studies, the turbidimeter did not operate correctly. Therefore, the conclusions were based solely upon visual growth while the instrument was being repaired. Yet in two tests using only visual readings, it was possible to evaluate this series of compounds.

It is interesting to mention at this point that the the turbidimetric readings are of great value in learning information about the dosage-response relations between a chemical and the test organism. This possibility is presently in the early stage of development. In many tests a logical series of decreasing turbidity readings results from increasing concentrations of an effective slimicide. This will be shown later. However, in this particular table, the value reported under test I for the 1:10,000 dilution of the *o*-hydroxy derivative is discrepant and illogical. The figure shown is the average of duplicate test tube readings of 21 and 29%. The next value of 62% is the average of 61.5 and 62.5%. Obviously the meter is not at fault, and the discrepancy in surviving bacteria at these dilutions indicates the need for further refinement of technique. Nevertheless this type of quantitative variation does not invalidate the bactericidal end point to be between 1:1,000 and 1:10,000.

Having established the reproducibility of this new technique for mercurials, five different phenyl mercury aqueous solutions were compared simultaneously against *Aerobacter aerogenes*. The bacteriostatic method was used. This study was similar to the one reported in Table IV using the agar-plate method. In addition, a fifth phenyl mercury solution (P806) was included. Again, all solutions were standardized to contain equivalent amounts of the phenyl mercury radical before dilution. Large increments in chemical concentration were planned so the inhibition at any dilution level would prove significant. The results are presented in Table VIII. It is apparent by inspection that differences in effectiveness exist between certain formulations. P806 proved most effective, producing complete inhibition at dilutions below 1:700,000. Three other formulations appeared to be equal by inhibiting at 1:600,000; namely, P200, N5DS, and P305. P302 was poorest, allowing abundant growth at all concentrations, almost equal to the controls.

Interestingly, these results confirm the findings obtained by the agar-plate method in Table IV. In that test P305, P200, and N5DS were equal against Aerobacter, but P302 was less effective. These results lead to the conclusion that molecular structure has a definite influence upon the toxicity of certain phenyl mercury compounds.

The inhibiting role of nutrient agar was confirmed by comparing the evaluations obtained from the agar-plate and synthetic medium tests (Tables IV and VIII). In Table IV all the mercurials except P302 exhibited complete bacteriostasis in agar at 1:50,000 dilution. Similar results in synthetic liquid medium occurred at 1:600,000 (Table VIII). Thus the nutrient agar medium reduced the apparent effectiveness of these compounds about 12 times which is of the same magnitude as the factor of 9.2 reported for P305 in a separate test shown in Table V. These factors of 9.2 and 12 are considered to be the same because the inhibiting concentrations for the agar-plate data of Table IV were based upon large increments of dilution. In that table, total inhibition occurred at 1:50,000 and growth at 1:100,000. Smaller increments would probably have eliminated this apparent difference. However, the effect of nutrient agar upon these mercurials was not the purpose of these two tests. A similar comparison for P302 could not be made because no end point was obtained for this compound in Table VIII.

Referring again to dosage-response relations, a glance at the turbidimetric data of Table VIII shows that readings for all the mercurials except P302 comprise a reasonable series; i.e., increasing chemical concentration produces decreasing turbidity. Therefore, to plot a dosage-response curve, the turbidimetric readings were plotted on semilogarithmic paper against their respective phenyl mercury concentrations. The results are shown in Fig. 1.

The single striking conclusion as a result of such plotting is that all of the phenyl mercury compounds except P302 exhibit similar slopes. This is considered by many investigators (*4*, *5*) to indicate a similar mechanism of action for analogous chemicals. In this particular

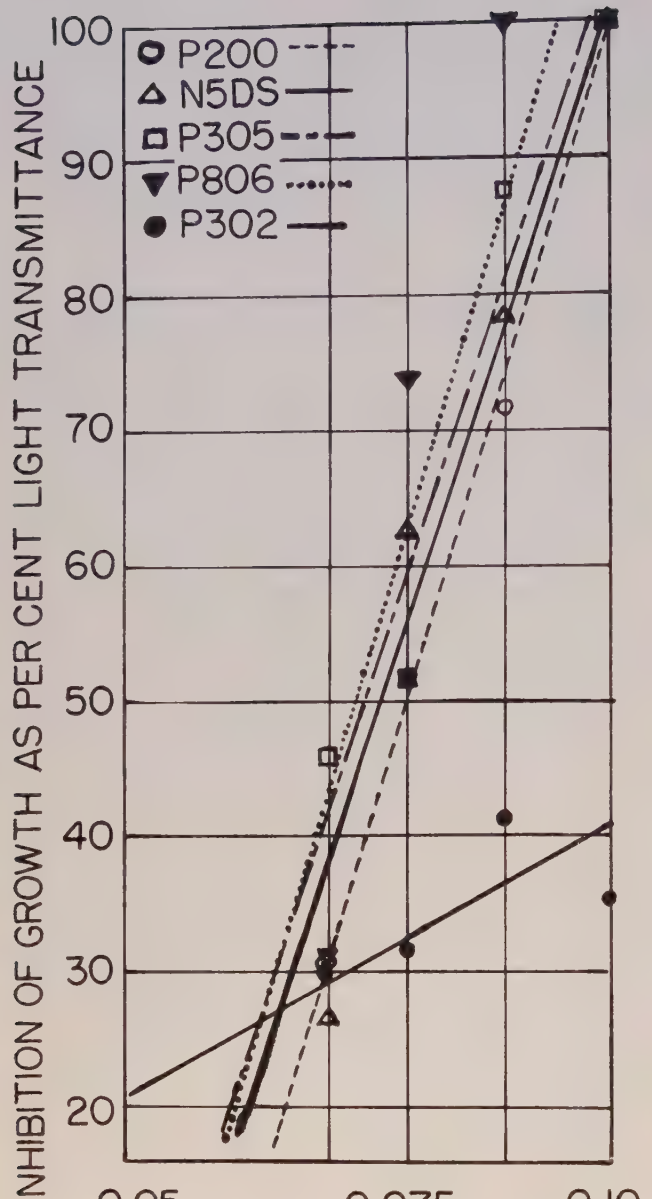

Fig. 1. Dosage-response relations of five phenyl mercury solutions and Aerobacter aerogenes

test the curve for P806 agrees in general in slope with the other three compounds, but it is effective at markedly lower dosages than the rest. This suggests that it has a similar mode of action but is more available to exert its toxicity at the site of action. Some workers like Horsfall and Rich (*6*) have recently suggested that such availability is associated with lipoid solubility as well as water solubility which enables the toxicant to penetrate the cell of the microorganism. For compounds having the same toxic group or structure, they have prepared derivatives possessing certain lipophilic radicals which increased the effective dosage without altering the dosage-response slope. P806 is believed to conform to this theory.

The only information derived for P302 in this test was confirmation for the third time of its inferior toxicity compared with the other mercurials studied. The inconsistent turbidimetric readings for this dilution series cannot be explained conclusively at this time. All the readings appear to be of the same magnitude and similar to the controls in the range of concentrations tested. A possible clue has since been noted in recent tests. Similar flat growth responses have been observed for other compounds at dilutions well beyond the germistatic concentration. Apparently the toxicant is so dilute that it produces no major growth effect that can be detected by the present test method.

CONCLUSIONS

The use of the commonly accepted nutrient agar-plate method to screen or compare potential slimicides has resulted in frequent variation in germicidal and germistatic data. Attempts to reduce such variation in this technique failed. All evidence indicated that the beef extract agar was the factor associated with the variation. When a synthetic liquid medium was used in a test tube procedure, it was possible to reproduce antiseptic data for compounds that could not be assayed with the agar-plate method. Several tests showed that selected phenyl mercurials were rated about 10 times less effective by the agar-plate method than by the synthetic medium technique.

The new synthetic medium procedure is described in detail with illustration of results from assays of mercurial and certain other organic compounds. The use of a turbidimeter in this technique permits the plotting of dosage-response curves. Such curves yield valuable information about the action of a chemical upon the test microorganism. The experimental results from tests comparing five phenyl mercury aqueous solutions show that molecular structure influences the toxicity of certain members studied, independent of the phenyl mercury content of the molecule. Four of the five phenyl mercurials exhibited the same slope of their dosage-response curves, suggesting that they possess the same mechanism of action.

The synthetic medium test was used to study the killing-time relationship for a water-solubilized phenyl mercury formulation (P200) and *Aerobacter aerogenes*. At the bacteriostatic dilution of 1:600,000 no cells survived a 4-hr. contact period, although 2 hr. permitted some growth. At 1:300,000 total bactericidal action occurred between 30 and 45 min.

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Drying of Insulating Board

H. C. JESSEN

The early history of the drying of insulating board is covered briefly. Then follows a general description of the various component parts of a modern roller drier as adopted for the drying of insulating board. This description covers the drier structure, the feeding section, the discharge section, the air circulating system, and these various parts are illustrated by examples from existing installations. The use of steam, gas, and oil as heating media is described and discussed and illustrated. A considerable portion of the paper is devoted to a discussion of the theoretical aspect of the drying of insulating boards in a roller drier. In this theoretical portion, the migration of moisture and evaporation is described and it is pointed out that the drying takes place in three distinct stages. The effect of air velocities and temperatures in each of these stages is described. In this portion of the paper a number of simple heat calculations are included. These pertain to gas-fired as well as steam-heated driers. Drier efficiencies are discussed and a formula developed for calculating the drier efficiency. In the last portion of the paper a description is included of steps to be taken when starting up a new installation. The final portion of the paper contains a discussion of the various methods to be considered when it is desired to increase the capacity of a drier.

THE insulating board industry had its modest beginning in 1908 up in Panatang, Ont., where a Manley Chew built a special forming press for making insulating boards from sulphite screenings. Even in those days the drying of insulating board was quite a problem. It was solved by the use of a tunnel drier equipped with multiple decks formed by carrying chains. This plant burned down and some of the machinery and equipment was moved to a plant at Midland, Ont., which later became the International Fiberboard, Ltd.

Between 1908 and 1915 very little activity took place in the insulating board field. At that time the Agasote Millboard Co. started making a fiberboard from old news. This company later changed its name to the Homosote Co. which name is more familiar.

The Agasote Co. was, the author believes, the first to use a roller drier back in 1915. The introduction of this practical and economical drying principle had a profound effect and made the manufacturing of insulating board by a continuous and economical method possible.

Later on there was quite a surge of interest in insulating board, and a number of companies were formed between 1920 and 1927.

Some of these pioneers were McAndrews and Forbes, Stewart Insulboard, Minnesota and Ontario Paper Co., Maizewood Products, and they all adopted the roller drier to handle their drying problems.

The first roller driers were built for the drying of veneer and did not utilize recirculation of air. When drying insulating board the water content of the wet board may be as high as 65% and the driving off of this large amount of water is a tremendous load on any drier, and represents also an expensive operation. It was, therefore, of particular interest to the insulating board industry when the Coe Manufacturing Co. introduced the principle of recirculation of air in 1923. Figure 1 shows an old cut illustrating this principle in its simplest form. Since its first introduction, recirculation has been adopted as standard and modified to suit the more complicated modern driers.

Originally a single drying zone was used. As the demand rose for greater capacity it became necessary to go to multizoning and also to widen the driers and use as many decks as practicable. Today a modern drier usually is more than 12 ft. wide, has at least eight decks, and uses up to five drying zones.

GENERAL DESCRIPTION

Drier Structure

The roller drier structure consists of a structural steel framework that may vary considerably, depending upon the length and width of the drier as well as upon the number of decks.

Since the drier is to operate at high temperature, it is very important to provide for proper expansion joints in the drier structure, and these joints should be designed in such a manner that each side of the drier will expand equally so as to avoid misalignment of the rollers.

Figure 2 shows a side view of a drier for insulating board where steam is used as a heating medium. A structural steel framework carries the "cages," or angle irons supporting the bearings in which the roller turns. In the picture the doors have been removed. These doors fit outside of the vertical steam header, and in modern designs the doors are usually hinged and equipped with quick opening locking devices.

The roof of the drier is commonly constructed from Tee iron between which corrugated sheet steel is placed and a layer of insulation placed on top of the corrugated sheets.

In older driers the return air ducts were often placed underneath the floor in an insulated concrete tunnel. This construction was both costly and was wasteful in heat utilization. Present-day construction places the air ducts above the drier and the drier floor is then simply a concrete floor covered with a suitable insulation.

Each roll is driven by a sprocket from a chain that runs the full length of the drier with chain hold-downs placed intermittently. The driving side of the chain is on top, and provision is made for supporting the return strand of the chain in a channel guide. Each deck has its own drive and return chain, and an automatic chain tightener must be provided for each of the drive chains.

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The bearings used are of two general types. One type in common use is the so-called "commercial" bearing, that is, roller bearings made without precision ground balls or races.

The other type is simplified sleeve bearings made of bronze, impregnated with a lubricant, or equipped with graphite inserts. Regardless of type used, the bearings

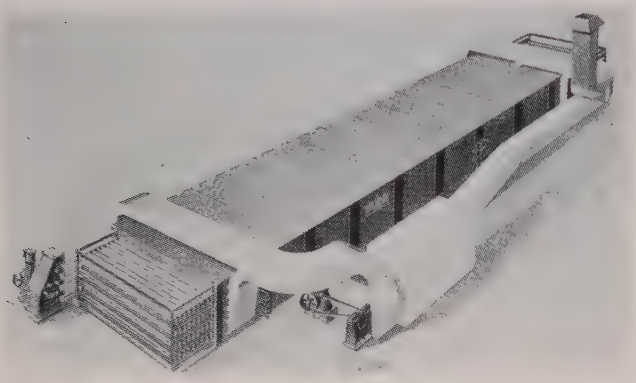


Fig. 1

are not lubricated due to the temperature in the drier. These bearings are relatively inexpensive, and they have to be replaced after about two or three years of operation.

With the advent of silicone lubrication, it may be possible to use lubrication to advantage; experience with regular grease lubrication has not been encouraging.

When drying a product of a reasonable stiffness and strength, the spacing of the supporting rollers is 12 in. If the product is quite short in length it may be necessary to space the rollers closer. It is essential that not less than four rollers are in contact with the product at any time. It this is not adhered to, the material to be dried will not run straight and will cause jamming.

In some cases, it is necessary to use a very close roller spacing. This is necessary in the case of insulating boards. They have a very high moisture content as they enter the drier and are structurally quite weak.

The practice is therefore to use a 4-in. roller spacing in the first section of the drier, followed by a gradual increase in spacing as the boards get drier and stronger. Since the standard roller diameter is 3 in. it is necessary to use very thin sprockets arranged in an overlapping pattern. Such overlapping pattern is shown in Fig. 3.

In a steam-heated kiln, the steam coils are placed between each deck with an extra set of coils above the top deck and under the bottom deck. Vertical steam headers are connected to these coils which may vary in design depending upon the steam pressure used. These steam coils are supported by angle irons fastened to the drier frame or to the "cages."

When direct heat is used, such as in gas or oil-fired driers, the same deck spacing is used, and the absence of steam coils makes these types of driers more accessible which is an advantage.

The circulating fans as well as the exhaust fans are placed above the kilns in modern drier designs, except where the lack of head room makes it necessary to go to a different arrangement. By placing the circulating fans above the kiln, the duct work carrying the circulating air can be supported on the drier structure itself. Since the fans are rather heavy and driven from large motors, they are supported by an independent structure.

Oil-fired driers present a special problem in that the furnaces in which the oil is burned are quite heavy and cannot readily be supported from a light structure above the drier. In such cases the drier building is sometimes designed as a two-story building with the oil-fired furnaces as well as the fans on a second floor above the drier. In other cases the furnaces are placed on the floor alongside the drier and duct work carried over to the drier.

When gas is used as fuel, only a lightweight insulated enlargement of the return air duct is required for the accommodation of the burners. The over-all weight of a gas-fired heater is therefore small and presents no particular problem.

In steam-heated driers it is customary to use banks of booster coils to reheat the circulated air before reentering the drier, and not to depend entirely on the heat given off by the coils inside the drier proper.

Such booster coil sections must be selected with some care depending upon the service conditions. As an example, "Aerofin" coils, or coils with a large amount of fins or extended surfaces, are not suitable for insulating board driers since the recirculated air contains a considerable amount of lint or fibrous material which will plug up the coils.

In insulating board driers it is therefore customary to space the fins wider apart and also to equip the booster coils with automatic or hand-operated cleaning devices similar to soot blowers in action.

When booster coils are used they can be mounted above the driers in a similar position as the direct-fired gas heaters. The old cast-iron steam coils were too heavy for this, and in older installations one therefore finds that the booster coils are located on the floor.

As can be noted from the figures, the sides of the roller driers are covered with removable doors. These

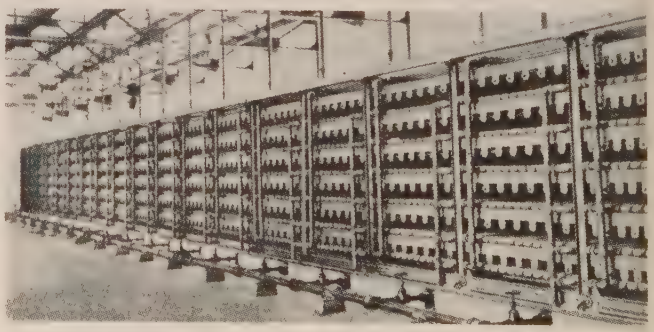


Fig. 2

doors are made of sheet metal with insulation between the inner and outer sheets. The reason for the use of sides made almost entirely of doors, is that occasionally one may have a "kiln jam"; that is, the product will pile up inside the drier. This can be caused by misalignment of the rollers, by worn-out bearings refusing to turn, or by rollers out of level. By having doors

the full length of the drier and by having inspection openings in the doors at regular intervals, such troubles can be readily detected and corrected before serious damage is done.

Easy access to the drier is also important when inflammable material is being dried. This is particularly important in the insulating board industry where a wood pulp board is being made. In driers used in this industry it is now customary to install special type of sprinkler heads inside the drier itself. These sprinkler heads are either set off by hand by the drier operator or controlled automatically by "rate of rise" heat actuating devices.

Feeding Section

One of the cost saving aspects of the modern roller drier is that a fully automatic feed mechanism can be used. The conventional feed section, as developed by Coe Manufacturing Co., consists of a so-called "tipple" which is a wide multibelt conveyor hinged at one end and equipped with an automatic hoist at the other end. The board to be dried enters this tipple from another conveyor and is placed in alignment with one of the decks in the drier. Figure 4 shows a view of the feeding section and tipple from Armstrong Cork Co.'s plant at Macon, Ga.

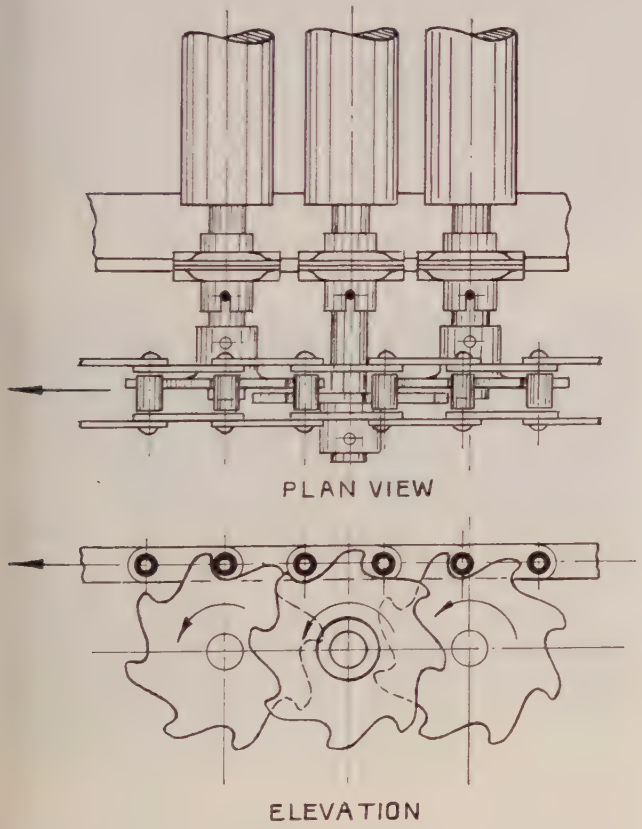


Fig. 3. Typical close center roller drive

As soon as the board leaves the tipple, the tipple hoist is engaged and raises or lowers the tipple to the next deck.

In a continuous process producing a sheet material, it is necessary to cut the sheet into suitable lengths before entering the drier, if the drier is of a multideck type. If such sheets came from the manufacturing process, cut to the proper length, but without any space between each sheet, the feeding tipple would not have time to select the next deck in the kiln. In order to provide a time interval for the tipple, it is therefore necessary to pull each sheet away from the following sheet as they are cut. This is normally done by a so-called "speed-up section" which is a roller conveyor

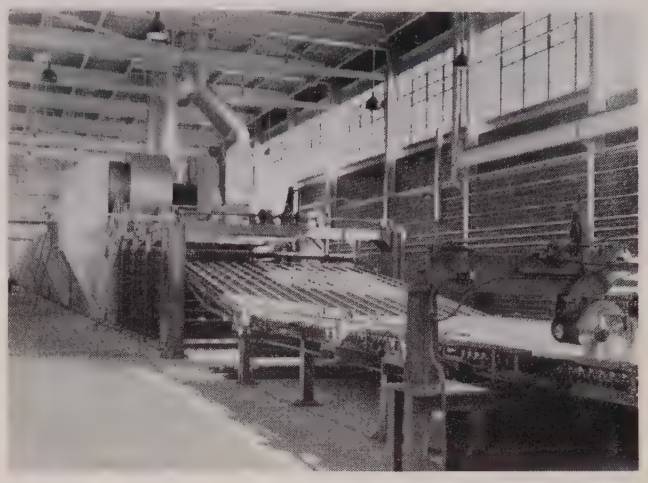


Fig. 4. Wet-end equipment Coe fiberboard drier, Armstrong Cork Co.

running at a speed at least twice as fast as the manufacturing process.

In Fig. 4 this speed-up section is located before the boards enter the transfer since a space between boards is required for the operation of the transfer as well as for the tipple.

On an eight-deck kiln the Coe tipple will engage the top kiln deck first, then drop to the next deck, and so forth, until the lowest deck has been engaged.

The tipple will then raise till the top deck is engaged again. When operating at very high manufacturing speeds, the longer delay between deck no. 8 and deck no. 1 is apt to cause trouble or force a slowdown. This can be easily overcome by designing the control mechanism on the tipple so that it will select every second deck except at the bottom going down and at the top going up, where the next deck is selected.

As the board leaves the tipple it enters a two-speed kiln section. This section must have a dual-drive arrangement so that the speed of each deck can be adjusted to that of the tipple when a board enters that particular deck. As soon as the board has left the tipple and has entered the two-speed section it must slow down to the regular kiln speed.

This is accomplished by driving the two-speed section from the kiln proper when the slow speed is used, and by driving the section by means of an independent high speed drive rig when the high speed is desired. A set of overrunning clutches is used for slow-speed drive take-off from the kiln decks, and magnetic clutches used at each deck for engaging the high-speed drive. The boards themselves actuate limit switches that will engage or disengage the high-speed drive clutches. Figure 5 shows the end of the tipple and the high-speed section at the Jarratt, Va., plant of Johns Manville Corp.

Note the motor that drives the high-speed section; the clutches and gearing are inside the enclosed gear box. Also note the tipple hoist and its counterweight enclosures.

Insulating boards are made in 4, 8, or 12 ft. widths. Most larger installations are now made in 12-ft. widths and the drier is made at least 1 ft. wider than the boards

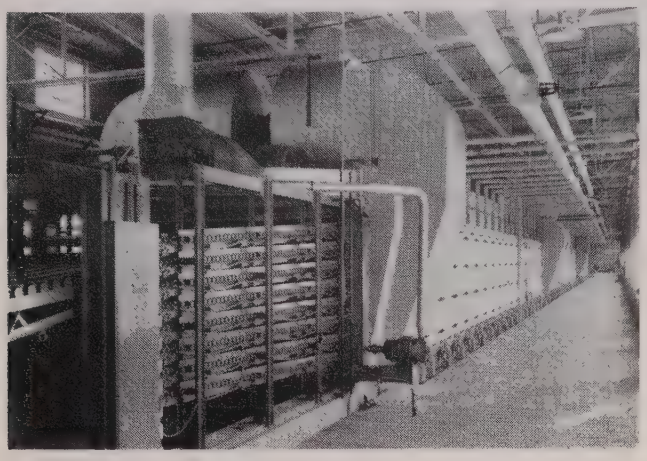


Fig. 5. 8-deck, 12-in. V.C., 13-ft. 6-in. roll steam-heated drier with automatic feeder, Johns-Manville Corp., Jarratt, Va.

so as to provide some leeway for side travel or misalignment.

Discharge Section

As the boards travel through the drier they will maintain the same relative position on each deck as they were fed into the drier. It is true that a certain amount of creep and shifting may take place inside the drier, but this would be of a minor nature.

It would therefore be possible to install a discharge arrangement almost identical to the feeding arrangement. This is not normally done since it is desirable to be able to discharge one particular deck as needed and feed the board into the next process, or into a suitable packaging unit.

In the insulating board industry it is customary to send the boards from the drier directly to a cut-up saw rig. When this is done an automatic discharge section is provided.

This automatic discharge section consists of a number of converging live rollers equipped with a drive arrangement which will speed up each board as it reaches the drive. Figure 6 shows such an arrangement as used by Johns-Manville at their Jarrat plant. A further improvement on this principle is the use of individual drive motors for each deck. In such cases the operator can select any deck and bring out the board from this deck and he can do this from a remote point by electric push buttons.

In case of special requirements, it is possible to work out an automatic or at least a semiautomatic solution permitting the minimum of attendance cost.

Air Circulation

In order to obtain uniform drying in a multideck drier it is necessary to have a strong circulation of heated air over the product to be dried.

Experience has shown that if the velocity of this air is reduced below a minimum point, the drying will vary too much from deck to deck since the air will avoid the longer passages and take short cuts wherever possible.

On the other hand, very high velocities increase the cost of operation, but it also increases the drying rate.

In modern design the air velocity is rarely less than 1000 or over 2500 f.p.m.

The older roller driers were rather short and had only one "zone," that is, only one air circulating system.

As the driers increased in length it was necessary to add additional circulating systems. Figure 7 shows this development in a somewhat more advanced stage. Note that the fans are of the double type with a single drive, and that the vent stacks are located on the pressure side of the fans. Also note that in the case of the single zone driers the air is introduced at one end of the drier. This latest practice makes it necessary to provide a good seal at this end, and this is quite difficult to do effectively. As a result, these old single zone driers had a tendency to leak hot air into the room at the pressure side of the air circulating system.

Modern practice for short driers is therefore to introduce the air in the center rather than at the ends to avoid having to seal against high air pressure.

On longer and more advanced driers the multiple zone system is used quite effectively and with this system there is no limit to the number of zones that could be used. Figure 8 shows an example of a three-zone drier with the zones of different lengths depending on the chilling effect from the product.

In order to obtain a good entrance velocity and to prevent leakage between zones, a so-called nozzle section is used at each deck. These are curved sheet

Fig. 6. 8-deck, 12-in. V.C., 13-ft. 6-in. roll steam-heated drier with automatic unloader, Johns-Manville Corp., Jarratt, Va.

metal guide nozzles that direct the air in the proper direction. These are located between decks and only high enough over the product to provide clearance. Sealing baffles are then also installed between zones to prevent leakage.

In modern practice it is customary to try to figure on approximately the same degree of temperature drops in

each zone, while the air volume in each zone is kept reasonably constant.

In this manner each zone can have the same size fan, which simplifies the construction. The product to be dried enters the drier in a very moist stage and absorbs heat from the circulated air very rapidly. It is important that the circulated air must not be cooled below

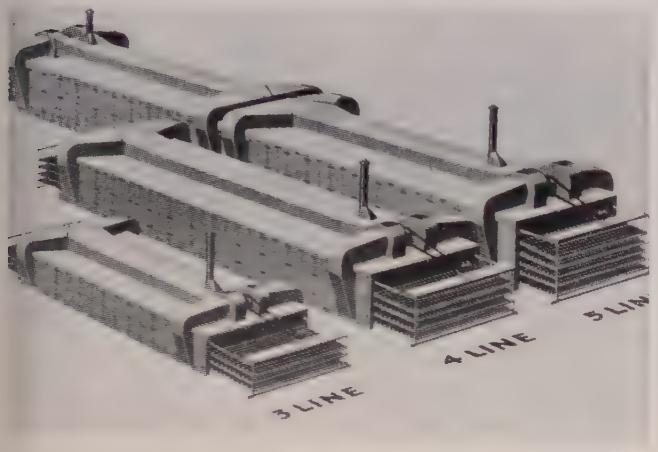


Fig. 7

the dew point, or condensation inside the drier will take place. As a result of these considerations, the air circulating zone at the kiln entrance end is quite short, and each zone is made longer as we move toward the discharge end.

In order to select the proper length of zones, the product to be dried must be studied carefully and some observations made as to how it acts under conditions similar to those in an actual drier.

Other points that also must be considered in selecting the best air circulating system are the sensitivity of the product to high temperatures at various degrees of moisture content, the percentage of moisture in the wet product, the heating medium available, the moisture migration, and vapor pressure developed inside the product.

Insulating boards made from wood pulp can stand temperatures of the circulating air of up to 600°F. when the board is still wet, that is, containing 50 to 60% moisture, while 300°F. air will definitely brown the boards when the moisture content has dropped to 8 to 10%.

In all modern roller driers, the principle of air circulation is utilized to its greatest practical extent. Usually all of these driers operate with air temperatures well above 212°F. even at the coolest end of each zone.

It is very good economy to return the hot air back to the system and to only bleed off enough steam and air mixture to get rid of the moisture that is driven off the product. On driers operating above 212°F. it is practical to go to a high degree of air circulation with resulting economies.

On driers operating with circulating air temperatures below 212°F. the water vapor must be absorbed by the circulated air, while the relative humidity of this air increases.

Theoretically, one could allow air circulation up to a point where the air discharged from the system would have almost 100% relative humidity. In actual practice, 85 to 90% is the upper limit.

On low temperature driers it has been found helpful to utilize dry and wet bulb thermometers on the discharge stacks to determine the relative humidity of the discharge air and thereby "close up" the system to the greatest possible extent. This is not practical in the insulating board industry.

Automatic instruments have also been tried but without notable success, and on a continuous process, such as a roller drier, a skilled operator will quickly learn the peculiarities and limits of his equipment and can adjust the exhaust dampers to the most economical setting.

Heating Mediums

Roller driers have been equipped to use a great variety of heating systems. We will mention here only types that have proved their merit in practical experience.

Steam. In the older driers steam coils were used between deck of the driers, and this simple method is still very much favored in locations and under con-

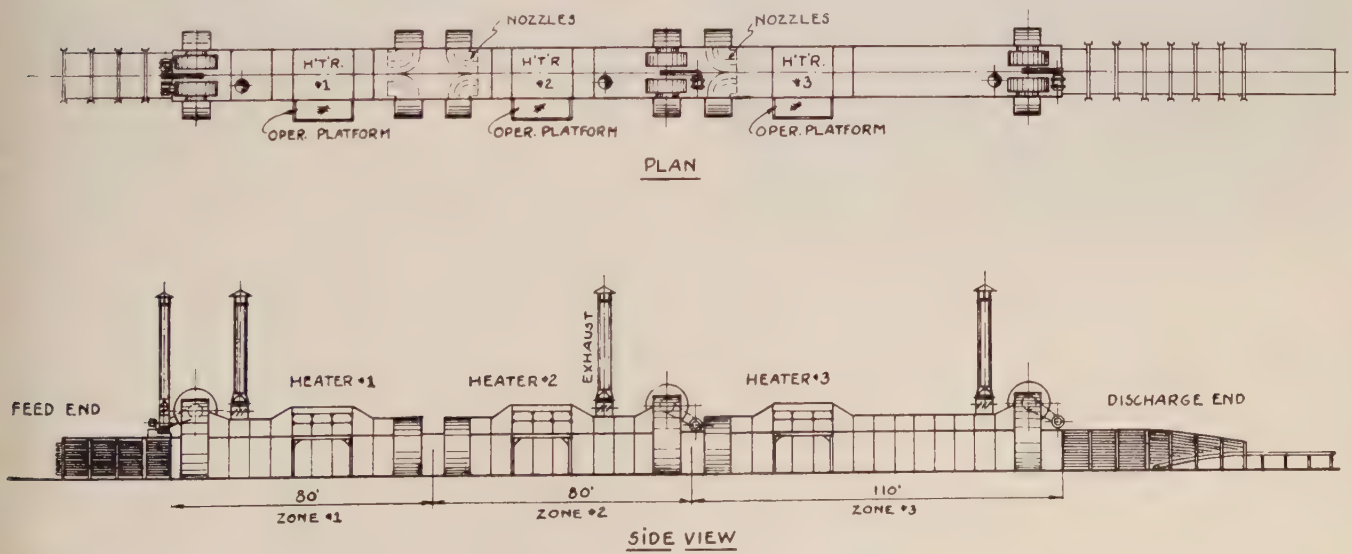


Fig. 8. Typical three-zone roller drier

ditions where steam is available at a competitive price.

The coils used to be made of return bends and straight pipes, or of the so-called "Bailey" coil design, where a small pipe is fitted inside a larger pipe and both fitted to a cast-iron header with two passages. In modern practice all-welded coil construction is used and these can be designed for much higher pressures than was the case for the older designs.

It has been found very advantageous to avoid the use of screwed connections inside the drier proper. There is a good practical reason for this, namely, that a screwed joint may develop a leak which would be very difficult to stop in the cramped space inside the drier. With the advent of all-welded coils a great deal of leakage trouble has been eliminated.

In order to provide proper drainage, the coils must be installed with a slight pitch toward the drain connection, and since the temperature in the drier, and consequently, the steam pressure drop through the coils, varies, it is best to provide individual steam traps for each group of coils. The older practice was to drain a large number of coils into a drain header which was then trapped. Due to the variation in cooling of the steam in the coils this caused trouble with flooding of the lower coils in the cooler or entrance section of the drier.

Steam is a very flexible heating medium if it is possible to use high steam pressure in the entrance of the kiln where the load is the highest. Some kilns use up to 300 lb. steam pressure in the entrance section with pressures down to 50 lb. in the discharge section.

In some cases progressive use of steam has been tried by the use of high pressure supply steam at the entrance section and the use of flash steam progressively in the remaining sections.

In general, such systems, while theoretically of considerable advantage, have not met with a general acceptance, mostly because of rather complicated steam piping. Another factor that has retarded progress in this direction has been the tendency to force the drier to the utmost in order to obtain the highest production. In the majority of cases, the drier has been a bottleneck in the production and it has been found economically sound to strive for the greatest production at a sacrifice in steam economy.

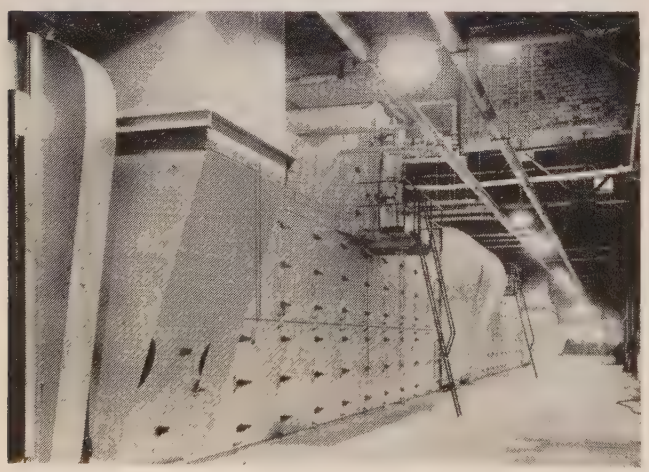


Fig. 9. General view of steam side, 10-deck, 12-in. V.C., 13-ft. 6-in. roll drier, M & O Paper Co.

A special problem exists in the handling of the condensate from the steam coils in the drier. Ordinary steam traps on each group of coils which trap discharge into a common return header have not proved entirely satisfactory. A better way is to install condensate

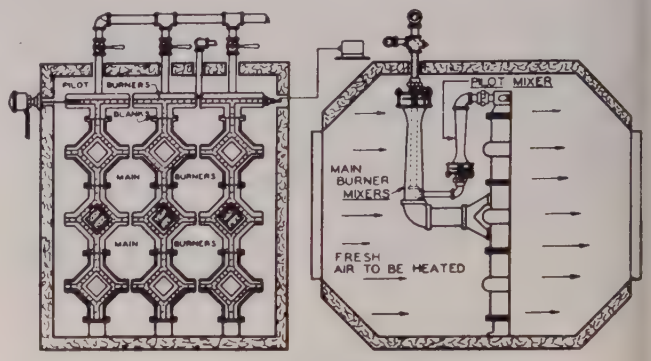


Fig. 10

booster pumps for groups of coils and to make special provisions for the removal of entrained air or gases in the condensate. Figure 9 shows a steam-heated ten-deck drier used at the Minnesota and Ontario Paper Co.

Gas. Gas fuel is probably the most ideal fuel for the roller drier, and great strides have been made in developing suitable types of burners and burner arrangements for use on roller kilns.

When gas is available, the costly steam coil system can be dispensed with and the gas simply burned in an enlargement of the return air duct. The combustion gases from the burning of the gas then simply mixes with the recirculated air and heats this up to any desired degree. Here, with gas is meant any type of gas such as natural gas, refinery gas, manufactured gas or so-called "bottled gas" (butane, propane, etc.). It would even be possible to use producer gas provided this had been properly cooled, scrubbed, and purified.

The gas burner type now commonly used is either "line burners" such as is made by Maxon Premix Co., or "diamond" type line burners as made by Western Products Co. Figure 10 shows how this "diamond" type is installed, and that they can be arranged in any suitable pattern to suit the cross section of the enlarged duct.

Both of these types of burners are supplied with a gas-air mixture produced either by inspirators or by power driven gas-air mixers. This air-gas mixture is forced into the burner openings at a velocity slightly higher than the speed of the flame propagation, thereby preventing backfiring.

There are several types of inspirator arrangements in use. The simplest is the use of a plain inspirator which will take the air for mixing with the gas from the surrounding air. This system is very effective when the combustion chamber is under suction or at neutral pressure, but cannot be used when the combustion chamber is under a sizable positive pressure. In that case, one is forced to use an inspirator of a design requiring combustion air supplied under pressure. A system utilizing this arrangement is shown on Figure 11.

In gas-fired driers of Coe design the combustion chamber is placed on the pressure side of the circulating fan. Air supply to the inspirators is therefore supplied under pressure by means of a blower at each combustion chamber. Other driers frequently use a plain inspirator, and in that case the combustion chamber is located on the suction side of the circulating fan.

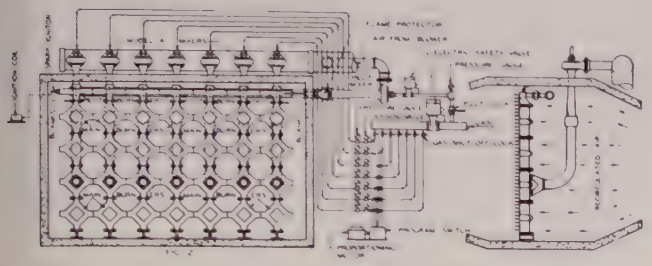


Fig. 11

There are advantages and disadvantages to both methods. The main factor to consider is the effect of either system upon the circulating fan. If the combustion chamber is on the suction side of the fan, the temperature of the air passing through the fan is much higher than if the combustion chamber is located on the discharge side. For high-temperature work, say air temperatures above 350°F., it is best to place the combustion chamber on the pressure side of the fan. If this is not done the difference in power required for starting the circulating fan, cold, compared to the power required when handling hot air, is so much that special restrictive dampers or special motors are required.

There is an added advantage in this arrangement in that a separate exhaust fan can be omitted and the necessary venting can readily be obtained by the installation of a vent stack between the fan discharge and the combustion chamber.

The disadvantages are mainly that the combustion chamber is under pressure which makes it difficult to do any adjusting or repairs during operation.

On all gas-fired driers it is customary to equip all burners with elaborate safety devices to insure against explosions.

These safety devices consist of flame-rod protection for the burners and of time relays requiring a certain venting period before a burner can be started. In addition, protection is provided against failure of gas pressure or failure of electric power. When these safeguards are installed the burners are normally started by a spark plug ignition system which is both convenient as well as safer than starting by means of a torch.

On modern installations of considerable size it is quite common to use a program controller which will automatically increase or decrease the number of burner banks in operation to suit the load.

Figure 12 shows an eight-deck gas-fired drier as installed at the National Gypsum Co.'s plant at Mobile, Ala.

Oil. Oil has proved itself to be a very satisfactory fuel for direct firing of roller driers, but the use of oil has not met with a ready acceptance for insulating board driers.

For those that may be interested in the use of oil-fired driers, the following information based on experience in the plaster board industry may be of interest.

When oil is used it is necessary to provide brick-lined air heaters and to maintain a high temperature in the firebox and to blend the high-temperature combustion gases with the recirculated air. The air heaters are placed on the suction side of the circulating fans and due to their heavy weight, they are either placed on the floor above the drier or on the floor alongside the drier.

The most satisfactory air heater design consists of a firebrick-lined tube suspended inside the insulated air mixing chamber. This tube is supported at both ends and the firing end fixed while the other end can expand and contract.

The selection of burners is quite important. Straight mechanical burners have not proved satisfactory because of their limited turn-down rate and also because of the flared flame pattern. Burners utilizing low or medium pressure atomizing air have worked out quite well and are generally preferred.

Many different grades of oil have been used from heavy bunker "C" fuel oil to light furnace oil. When using heavy oil it has to be heated quite high to insure good combustion, and the firebox temperature kept quite high, around 2000°F. or better, otherwise smoke results which would damage the product. The combustion chamber temperature is controlled by increasing or decreasing the amount of circulated air passing around the combustion tube.

The safety protection for oil-fired furnaces is similar to what is provided for gas-fired furnaces, and automatic control is possible but not quite as reliable as for gas-fired furnaces.

Fig. 12. Operating side gas-fired Coe fiberboard drier, National Gypsum Co., Mobile, Ala.

When considering the use of oil as a heating medium it is very important to allow for the effect of the sulphur in the oil. A sulphur content of over $^1/_2\%$ will definitely cause a browning of organic material. This can be overcome by the use of a neutralizing medium injected into the flue gases. One such convenient method is the use of ammonia gas as a neutralizer.*

* Patented.

Figure 13 shows a typical heater design of a type that has been found satisfactory and economical in maintenance.

Generally speaking, the maintenance of oil-fired furnaces is higher than the maintenance of gas-fired heaters but still considerably lower than the maintenance cost of steam-heated driers.

Maintenance

A roller drier consists of a large number of moving parts operated under rather adverse conditions.

All these moving parts, such as rollers, bearings, and chains, must be periodically inspected and replaced. Bearings last from two to four years, chains from three to six years, and rollers will last a long time if they are not damaged by fires.

Great strides have been made lately in introducing better bearings, stronger chains, and new improvements are coming out all the time.

As of today the maintenance cost is not excessive, and may vary from 5 to 10% of the value of the installation per year. This depends, of course, upon the number of hours operated per year.

Maintenance planning is particularly important in the operation of a roller drier. Should there be a number of bearing failures causing "dead" rollers, such a condition will cause a serious kiln jam and possibly a bad fire. Chain breaks during the operation are equally serious.

For these reasons it is very important that an inspection program be followed and that the drier is maintained in good condition at all times.

THEORETICAL CONSIDERATIONS

Moisture Migration and Evaporation

The nature of the material to be dried should be carefully studied in order to arrive at the proper proportions of a roller drier. Materials, such as insulating boards, enter the drier with a very high moisture content; other material may only be painted and the drier used to remove a small amount of solvents.

We shall here only concern ourselves with conditions where there is a substantial drying function, that is, a removal of moisture, to be performed.

The evaporation of water from a product can be said to pass through three periods, namely, (1) the constant rate period, (2) the uniform falling rate period, and finally (3) the varying falling rate period.

During the first of these periods the surface of the product remains wet and the moisture migrates to the outside at a speed fast enough to keep the surface thoroughly wet.

During this period the evaporation proceeds at a rate that would be constant if air temperature, vapor pressure, and velocity remained constant. At the end of this period we reach a point in the drying process when the moisture no longer comes to the surface as fast as it is evaporated. This point is usually called the *critical moisture content point,* and we now enter the second stage of drying.

At this stage the migration of moisture from the interior of the product to the surface proceeds at an insufficient rate to maintain a wet surface, and during this stage the surface gradually dries out.

This drying stage is sometimes called the *unsaturated surface drying* stage.

The final stage is often called *subsurface drying.* In this stage the drying takes place at a constantly falling rate until we reach what is termed the *equilibrium point* which is reached when the vapor pressure of the moisture in the air balances the vapor pressure of the moisture in the material.

In the design of roller driers insufficient weight has been given to the physical laws governing drying and in only a few cases can one find designs that take full advantage of the possibilities.

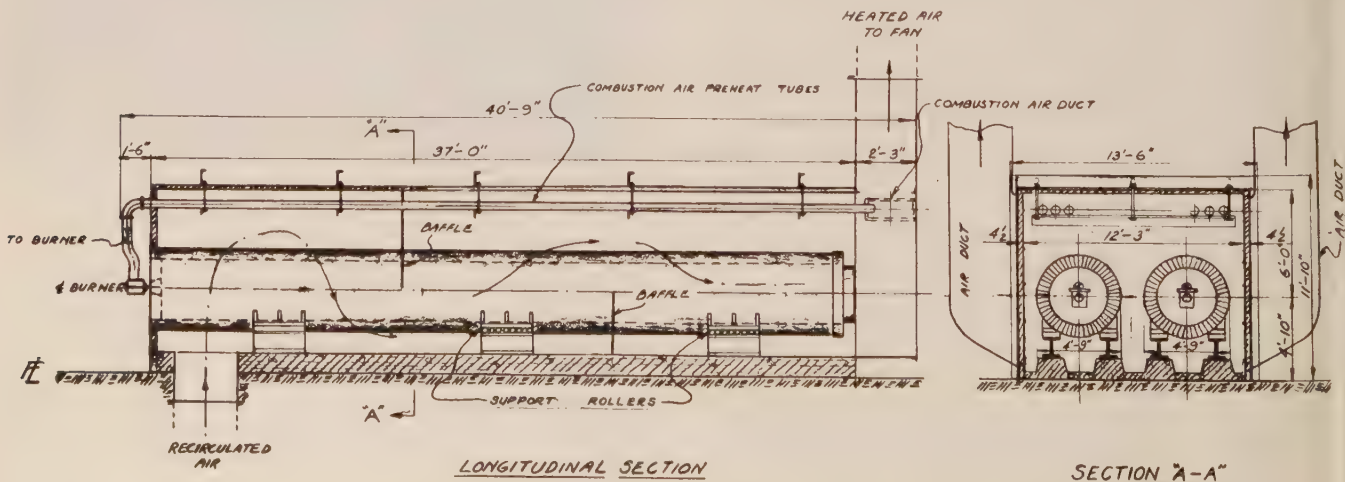
It is significant to note that the rate of drying during the first stage or constant rate period follows a formula that can be expressed as follows:

$$R = C \cdot S \cdot V^{0.8} (DT) \qquad (1)$$

where

R = rate of drying; lb. of moisture per hr.
C = proportionality constant
S = area of product in contact with air, sq. ft.
V = air velocity, f.p.m.
DT = difference between dry bulb and wet bulb temperatures of air, i.e., the wet bulb depression

In the above formula the drying takes place in proportion to the 0.8 power of the air velocity. In other formulas one finds other values from 0.6 power to 1.0 power. At any rate, all authorities agree that air velocity is very important in this stage.



LONGITUDINAL SECTION

SECTION "A-A"

Fig. 13

Table I. Drying Periods

Factor	*Saturated surface stage*	*Unsaturated surface stage*	*Subsurface stage*
Temperature	Increase in temperature increases evaporation rate	Increase in temperature increases evaporation rate	Increase in temperature increases evaporation rate
Humidity	Evaporation rate increases as humidity decreases	Evaporation rate increases as humidity decreases	No effect up to point of equilibrium
Air velocity	Evaporation rate increases with 0.6 to 1.0 power of air velocity	Evaporation rate increases with 0.6 to 1.0 power of air velocity	No effect
Air direction	Evaporation rate increases the more perpendicular the air blows on the surface	Evaporation rate increases the more perpendicular the air blows on the surface	No effect
Thickness of material	Evaporation rate proportional to the area exposed	Evaporation rate proportional to the area exposed	Drying time increases with the square of the thickness

It is also significant that during this stage in the drying, the material heats only to the wet bulb temperature of the surrounding air and, consequently, high dry bulb temperatures will not injure the material in this stage.

No suitable calculations of drying rate can be made for the second and third stages of drying since the capillary structure of the material, resistance to moisture migration, and other unknown factors, enter the consideration, and one is here forced to depend on carefully conducted laboratory tests.

It is possible, however, to tabulate roughly the effect of various conditions so as to serve as a guide in the design of the drier. Such a table is given above:

From the above table it follows that it is of no advantage to use high air velocities in the subsurface stage of drying, while high velocities are very beneficial in the other stages of drying.

In actual practice one finds that the rate of evaporation is so much higher in the first zones of a drier that this in itself makes it necessary to use shorter zones, otherwise sufficient heat cannot be introduced.

From Table I it is apparent that it is difficult to predict the drying time needed for similar materials, but of different thicknesses. In the saturated surface stage and the unsaturated surface stage the drying time for these stages will vary approximately in proportion to the thickness. In the subsurface stage, the drying time will increase with the square of the thickness.

From the above, we can only conclude that the over-all drying time for all three stages will increase *more* than the proportionate increase in thickness but *less* than the square of the increase in thickness. Actual practical results from numerous driers handling plaster board and insulating board show that the drying time will go up at a rate of from 1.5 to 1.8 power of the thickness.

Many products are hygroscopic in some degree. Such products will absorb moisture when left stored in a warehouse, and this absorption stabilizes itself usually in a range 6 to 10%. From this consideration it should therefore be unnecessary to dry any material below this hygroscopic equilibrium point.

Practical experience proves, however, that sheet material very often comes out with the surface overdried and the core underdried. The over-all moisture content may be below the equilibrium point, but the core is not dried sufficiently. During storage such product would absorb moisture from the surrounding air into the overdried surface, rather than from the core and the result would be a wet product. Consequently, one should figure on having to dry the *core* of the product to the equilibrium point, even if this means that the average moisture content is well below the equilibrium point.

Another reason for the need for apparent overdrying of a product is that one may be troubled with oxidation of oils and resinous products. Such oxidation will cause spontaneous combustion. In such cases it is customary to dry the product rather hard, and to rewet the surfaces after drying. Such procedure tends to stabilize the product and prevent spontaneous combustion.

Heat Requirements

When designing a roller drier one must obtain the following basic data: (a) capacity required, (b) moisture content of product entering drier, (c) moisture content allowable in the dried product, (d) specific heat of material to be dried, (e) maximum permissible air temperature that the product can be exposed to without damage, (f) temperature drop in each zone, (g) drying time, and (h) per cent of circulation.

Past experience from existing installation is, of course, very valuable and the designer can then proceed without much risk of errors. In the case of a product never before dried in a roller drier, the safest method is to collect sufficient and reliable data by laboratory tests.

Questions listed under a, b, c, and d can, as a rule, be readily determined. Simple tests will give a fairly accurate answer to question e. The most difficult questions to be answered are those listed under f and g, since laboratory drying ovens are rarely of a type that will readily yield results directly applicable to full-size installation.

The drying time can be obtained fairly easily if one has laboratory equipment with good temperature control and means for measuring the air velocities.

Properly designed laboratory driers will also give some good clues as to the probable temperature drop under air velocity conditions, but one rarely can afford to use laboratory driers of sufficient length to give reliable information regarding this important factor, and it is here that the designer's experience and judgment have to be relied upon.

There is quite a difference between a steam-heated drier and a drier utilizing gas or oil as the heating medium. In the case of a steam drier a major portion of the heat is provided inside the drier proper by means of steam coils augmented in some cases by preheating coils in the circulated air stream.

In a gas or oil-heated drier, all the heat must be supplied outside of the drier proper by heating the air before it enters the drier. As a consequence, the volume of circulated air in a steam-heated drier is not too critical and the volume can be held down to a point sufficiently to avoid stratification. In a gas or oil-heated drier the heat available is directly proportionate to the amount of air supplied and the temperature drop in each zone.

The air temperature curve in a steam-heated drier will usually be quite different from the temperature curve in a gas or oil-fired drier. This difference is quite pronounced if a uniform steam pressure is used, and less so if higher steam pressure is used in the "wet" end than in the "dry" end.

As the material heats up, the temperature of the circulated air will rise in a steam-heated drier, while just the opposite can be obtained in a gas or oil-heated drier by control of the circulated air temperature.

In case of material susceptible to burning or scorching, the oil or gas-fired driers have a decided advantage.

Gas or Oil-Fired Driers. Assuming that the following data have been assembled:

Capacity needed = A (lb. per hr., moisture-free)
Moisture content in material entering drier = a (%)
Moisture content in material leaving drier = b (%)
Specific heat of material = c (B.t.u. per degree per lb.)
Temperature of material entering drier = t_e (°F.)
Temperature of material leaving drier = t_l (°F.)
Total heat, B.t.u. per hr. required for drying = K

The amount of material entering the drier (wet weight) is:

$$A \cdot \left(\frac{1}{1 - (a/100)}\right) \qquad (2)$$

and the water content of this amount of material is:

$$A \cdot \left(\frac{1}{1 - (a/100)}\right) \cdot \frac{a}{100} = A \cdot \frac{a}{100 - a} \qquad (3)$$

The amount of water dried out can be expressed as follows:

$$A \cdot \frac{a}{100 - a} - A \cdot \frac{b}{100 - b} = A \cdot \left(\frac{a}{100 - a} - \frac{b}{100 - b}\right) \qquad (4)$$

In order to determine how much heat is theoretically needed to perform the drying function, we find that the following heat-consuming functions must take place:

1. The moisture-free portion of the product must be heated from entrance temperature t_e to outlet temperature t_l.
2. The water content retained in the material when leaving drier must be heated from inlet temperature t_e to outlet temperature t_l.
3. The water to be dried out must be heated and evaporated. The latent heat of water at 212°F. and atmospheric pressure is 970 B.t.u. per lb. The latent heat will vary from 1020 B.t.u. at 130°F. to 960 B.t.u. at 230°F., and in a roller drier operating with air circulation temperatures well above 212°F. it has been considered sufficiently accurate to use the latent heat at 212°F. and to add to this the heat required to raise the water temperature from inlet temperature t_e to 212°F.

Expressing this in a formula we have the following:

$$K = A \cdot c(t_l - t_e) + A \cdot \frac{b}{100 - b} \cdot (t_l - t_e) + A \cdot \left(\frac{a}{100 - a} - \frac{b}{100 - b}\right) \cdot 970 + A \cdot \left(\frac{a}{100 - a} - \frac{b}{100 - b}\right) \cdot (212 - t_e) \qquad (5)$$

or rearranged

$$K = A \cdot \left[(t_l - t_e) \cdot \left(c + \frac{b}{100 - b}\right) + \left(\frac{a}{100 - a} - \frac{b}{100 - b}\right) \cdot (1182 - t_e)\right] \qquad (6)$$

From a design angle and in order to have sufficient heat capacity, one should provide air heating capacity or steam coils so as to take care of the worst conditions and assume an efficiency of 50%. The capacity of the heaters should therefore be:

$$\frac{100}{50} \cdot K \text{ or } 2K \qquad (7)$$

Past experience has indicated that the number of drying zones should be based on the length of the kiln. As a general rule one should use a zone per each 100 ft. of kiln length. This is only an average figure, and it does not mean that each zone should be of the same length, but that the zones in the "wet" end would be less than 100 ft and that the zones in the "dry" end considerably longer than 100 ft.

The heat delivered from the heaters in each zone can be readily calculated from the following formula:

$$H = P(t_2 - t_1)c_a \qquad (8)$$

where

H is B.t.u.'s per hr.
P weight of air circulated, lb. per hr.
t_2 is temperature of air leaving heater, °F.
t_1 is temperature of air entering heater, °F.
c_a is specific heat of air

It is to be noted that this formula is not strictly correct since no consideration has been given to the combustion gases produced by burning of the fuel in the heater. The weight of the combustion gases is so small compared to the circulated air volume that it can be ignored.

The total heat produced from a multizone kiln would be the sum of the heat generated in each zone, or

$$H_{\text{total}} = H_1 + H_2 + H_3, \text{ etc.} \qquad (9)$$

In order to determine the weight of air handled through each heater one must determine the volume and temperature of the air handled by each circulating fan and deduct from this the amount of vented air. This is in case one is considering a system where the heater is on the pressure side of the fan.

In case the heater is on the suction side of the fan, the vented air will be removed by a vent fan before entering the heater and will not affect the calculations.

The amount of air discharged through the vent stacks can be varied a great deal and will vary with the seasons.

If the temperature of the vented air is above 212°F. the air has the ability to carry with it an unlimited amount of steam vapor, and it would be theoretically possible to get along with a very small amount of vented air. In actual practice one should figure on about 10% venting in the dry zones and up to 30% in the wet zones all depending upon the moisture content of the product entering the kiln. Should for some reason the temperature drop in the wet end be excessive, so that the temperature of the vented air drops below 212°F. the need for venting goes up sharply because the vented air can then only remove steam corresponding to the saturation point.

For this reason it is important in design of roller kilns that the wet end zones be kept short to avoid excessive temperature drop and that high air velocities be used in the wet end zone which also will reduce the temperature drop.

In most cases of drying one should avoid having to use vented air temperatures below 212°F. since air near the saturation point may get in contact with local cold spots and cause condensation and dripping of water on the product.

Such condition will frequently cause rejects which is costly.

Steam-Heated Driers. When considering a steam-heated drier the basic heat requirements will be the same as for oil or gas-heated driers.

This required heat volume has to be provided from the steam coils in the drier proper and from banks of booster coils that one may use.

Since the heat is supplied all along the drier and mainly inside the drier, one has to calculate the heating surface required.

The heat supplied from steam coils suspended in an air stream consists of two portions; namely, heat from radiation and heat from convection.

The over-all heat transfer is also frequently, used instead of calculating the radiation and convection separately. The following formula† expresses the total heat transfer as follows:

$$H = U(t_s - t)_m \qquad (10)$$

where

H = total heat transfer in B.t.u. per hr. per sq. ft.
U = B.t.u. transmitted per sq. ft. per hr. per degree temperature difference
$(t_s - t)_m$ = mean temperature difference between the two sides of the surface

U has been experimentally determined by several. We will use the formula developed by Buffalo Forge as being the most accurate for industrial application. This is as follows:

$$U = \frac{1}{0.0447 + (50.66/V)} \qquad (11)$$

Where V is the velocity of air through the clear area of tubes.

In a roller drier we do not have a condition where any standard heat transfer formula can be used. At best we can only obtain an approximation. Due to the fact that the steam coils are partially obstructed from the air flow, the above formula will give too high values, and from a design angle one should be very conservative and make sure that sufficient heating surface is provided.

Heat transfer from heating coils used as booster coils follows the same formula, but in that case the mean temperature will be calculated as follows:

$$(t_s - t)_m = \frac{(t_s - t_1) - (t_s - t_2)}{\log_e \cdot \left(\frac{t_s - t_1}{t_s - t_2}\right)} \qquad (12)$$

where

t_s = temperature of the steam
t_1 = temperature of the entering air
t_2 = temperature of the leaving air

† From "Fan Engineering," Buffalo Forge Co., 4th ed.

and the coefficient of transmission U found from:

$$U = \frac{C_p \cdot G}{S} \log_e \cdot \left(\frac{t_s - t_1}{t_s - t_2}\right) \qquad (13)$$

where

C_p = specific heat of air
G = weight of air in lb. per hr. passed through heater
S = total heating surface

The amount of heating surface (in square feet) required may be calculated approximately from the following formula:

$$S = (0.1119Q + 127A) \cdot \log_{10} \cdot \left(\frac{t_s - t_1}{t_s - t_2}\right) \qquad (14)$$

where

S = sq. ft. of heating surface
A = clear area of heater
Q = cu. ft. of air at 70°F.

For each kiln zone equipped with a booster heater we have the following equation:

$$Z_1 = H_{\text{coils}} + H_{\text{booster}} \qquad (15)$$

where

Z_1 = total heat absorbed in zone 1
H_{coils} = heat from steam coils inside kiln
H_{booster} = heat from booster coils

The total heat absorbed is the sum of the heat absorbed in each zone or

$$Z = Z_1 + Z_2 + Z_3, \text{ etc.} \qquad (16)$$

Heat Balance and Efficiency

The heat balance of a roller drier can be expressed in the simplest form as follows:

$$H = P_s + P_w + V_a + V_w + R \qquad (17)$$

where

H = total heat supplied to drier, B.t.u. per hr.
P_s = heat required to heat the moisture-free portion of the product from entrance temperature to discharge temperature, B.t.u. per hr.
P_w = heat required to increase temperature of water content in the dried product from entrance temperature to discharge temperature, B.t.u. per hr.
V_a = heat contained in the vented air, B.t.u. per hr. less heat contained in the same weight of air at room temperature
V_w = heat contained in the vented moisture or steam less heat contained in the same amount of water at inlet temperature, B.t.u. per hr.
R = radiation losses and leakage losses, B.t.u. per hr.

In this formula the small amount of heat that is present in the form of water vapor in the infiltrated air used for combustion or make-up air is ignored.

Usually one can readily measure P_s and P_w. It is somewhat more difficult to measure V_a and V_w but this can be done by measuring the temperature of the vented air-steam mixture, the volume by pitot tubes, and the dew point can be found by determining the fogging point temperature when the air-steam mixture is discharged against a polished container filled with a mixture of hot and cold water and by regulating the temperature of this mixture until fogging just occurs.

The total heat supplied represented by H can be measured, either by measuring the steam consumption as for a steam-heated drier or by measuring the gas or oil consumption.

The radiation and leakage losses represented by R can normally only be found from the formula.

To determine the efficiency of a roller drier it is usual to define this as the percentage of heat utilized for useful work and to consider it useful work to heat up the product from entrance temperature to discharge temperature, as well as the work done by evaporating the water dried out.

We can therefore express the efficiency by using formula (6) as representing 100% efficiency. The following formula will apply:

$$E = \frac{100}{H} K \qquad (18)$$

where

E = efficiency in percentage
H = total heat supplied to drier, B.t.u. per hr.
K = total heat required for performing the useful work

From formula (6) we have an expression of K as follows:

$$K = A\left[(t_1 - t_e)\left(c + \frac{b}{100 - b}\right) + \left(\frac{a}{100 - a} - \frac{b}{100 - b}\right)(1182 - t_e)\right]$$

Substituting, we have:

$$E = 100\,\frac{A}{H}\left[(t_1 - t_e)\left(c + \frac{b}{100 - b}\right) + \left(\frac{a}{100 - a} - \frac{b}{100 - b}\right)(1182 - t_e)\right] \qquad (19)$$

where

A = total weight (dry) of product to be dried, lb. per hr.
H = total heat supplied, B.t.u. per hr.
t_1 = temperature of product leaving drier
t_e = temperature of product entering drier
c = specific heat of material to be dried
a = moisture content in material entering drier in percentages
b = moisture content in material leaving drier in percentages
E = efficiency of drier

Normally, roller drier will perform at an efficiency from 50 to 75% when a substantial drying load is carried, such as is the case when drying insulating boards or gypsum boards. When used for drying of paint or for similar purposes the efficiency drops very sharply since in such cases the drying load is insignificant compared to heat losses from radiation and other sources.

Performance Charts

In order to study the actual performance of a drier it is very helpful to collect performance data and have these plotted on a chart. An example of this is shown on Fig. 14.

This chart shows the per cent solids and the per cent of water in the board. In addition, the circulated air temperature has been plotted. Note that this chart pertains to an eight-deck drier and that the drier speed is listed as being 4 f.p.m. With this is meant that each deck is operating at this speed, and the drier can therefore be fed at a rate of 32 f.p.m.

The chart gives several significant data which would be of value in design of similar driers.

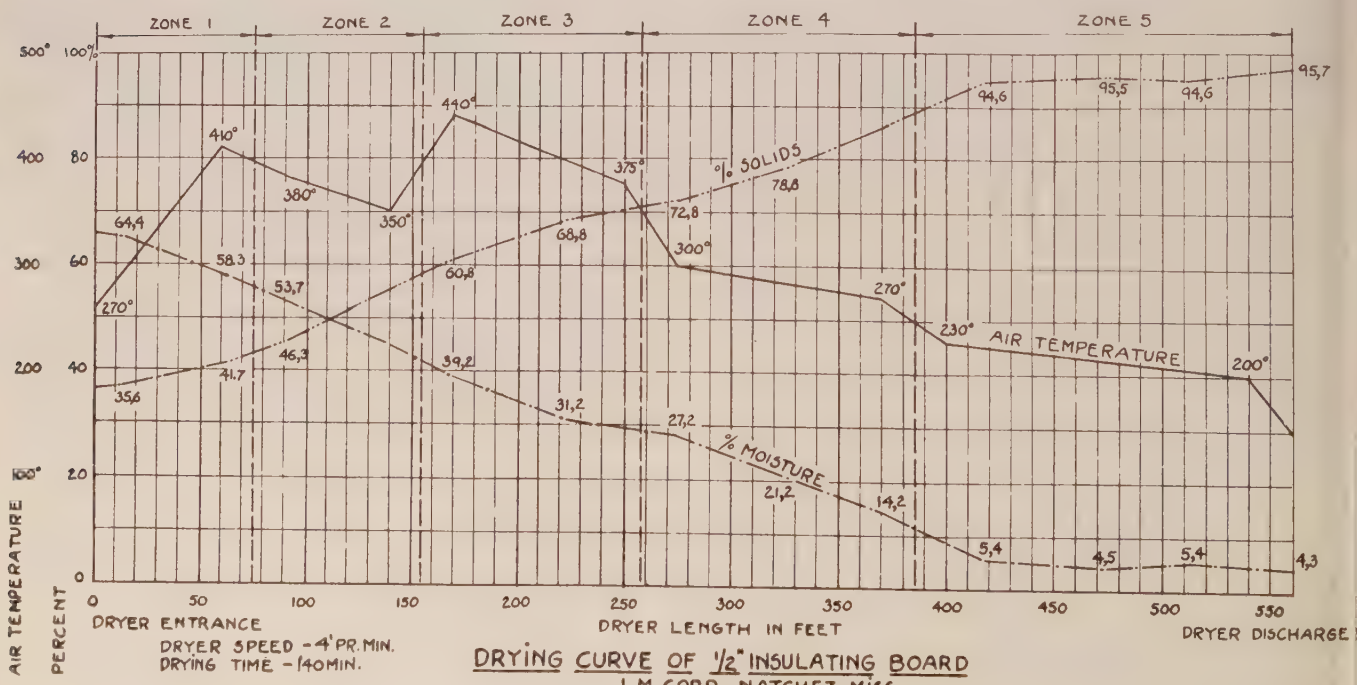
It shows that a straight line drying curve can be obtained by the proper selection of air temperatures, and that the drying was completed after a travel of about 450 ft. in the kiln. The remaining 110 ft. acted purely as a conveyor.

Note that there is a tendency for the dried product to absorb moisture even when exposed to temperatures in the range of 200°F.

Since this drier was designed for a much higher capacity the temperatures used are generally lower than what is used when operating at full capacity.

ADJUSTMENTS AND OPERATION

A roller drier is quite simple in principle but like most equipment of this type, it requires many adjustments



DRYING CURVE OF ½" INSULATING BOARD
J. M. CORP - NATCHEZ MISS.

Fig. 14

and operating experience before one can get the best results.

Before feeding boards to the drier the following should be checked:

1. Make sure that the drive operates properly and that all rollers are turning freely without binding.
2. Check roller alignments and test this by feeding single test boards through the drier and observe if there is any side motion. Side motion may be caused by high or low rollers or misalignment. Adjustments must be made to keep side motions to a minimum.
3. Check roller hold-downs and alignment of the sprocket with the drive chain. Misalignment of the sprockets will cause excessive sprocket and chain wear.
4. Check the operation of the chain tightener, and make sure that the take-up is weighted sufficiently to take out excessive slack in the return strand of each drive chain.
5. Check the operation of all circulating and exhaust fans.
6. Check if all temperature control devices are functioning properly. In gas-fired installations all safety devices such as flame control device, shut-off valves, etc., should be checked very carefully.
7. It is best to operate drier at approximately the operating temperature before feeding boards into the drier. During this time the expansion joints should be checked and made sure they operate properly. Roller alignment at operating temperature should also be checked.
8. Check sprinkler system and actuating devices.

As soon as the drier has been found to be adjusted properly and checked over, it will then be safe to begin feeding boards into the drier.

During this first trial run it is recommended that a good log be kept of the operation, particularly the temperatures in each zone, and that moderate temperatures be selected to start with.

The log should include moisture test for each deck so as to check the uniformity of drying.

During the test run one will invariably find that some decks are lagging behind in drying and that many adjustments to the air supply dampers will be required. These adjustments are quite easy to make, but since adjustments for one deck will affect other decks as well, it will normally take quite a number of runs before the drier has been properly adjusted.

It should be kept well in mind that the capacity of the drier is set by the slowest drying deck and that it will pay substantial dividends to spend considerable time to obtain the highest uniformity.

Steam-heated driers present a special problem in that it is necessary to make sure that the condensate drains properly from the coils and that air or gases are not entrapped.

For the purpose of checking the operation of the coils a portable surface pyrometer is very handy and well worth including as standard equipment.

Ample provisions for gas removal in the form of thermostatic air vents and test cocks at the top of each of the vertical supply headers are necessary.

In case the boiler water has been treated by a zeolite water softener the condensate will contain carbonic acid which at higher temperatures is very corrosive.

The pH reading of the condensate should be checked and if it is well on the acid side, steps should be taken either to neutralize the condensate or to change the water treatment method.

Frequently one finds that the drier is the bottleneck in the operation and that it would be desirable to increase the drier capacity.

For this purpose the following steps can be considered:

Increase in Temperature. This can be done readily in a gas-fired drier and is, of course, the first thing the operators will try. Should the existing gas burners be of insufficient capacity this can be corrected by either increasing the gas pressure by enlarging the orifice opening in the burner spuds or by adding burner sections.

A steam-heated drier is not as flexible and the temperature can be raised only by increasing the area of the booster coils or by increasing the steam pressure.

Improve the Air Circulation. If a check on the drier performance and temperature curves shows a considerable temperature drop of the circulated air from inlet to outlet in the zones, this indicates that the air velocity is too low. In that case the circulating fans could be speeded up, thereby reducing the temperature drop and improving drying.

It is to be noted that this is much more effective in the wet end of the drier than in the dry end.

Adding Length to the Drier. This is naturally a very effective method of increasing the capacity but also a costly one. If only a moderate increase is desired, the last or dry end zone could be lengthened without adding additional zones. This is the cheapest way. In that case one may have to increase the fan capacity and speed to compensate for the longer air travel.

If a substantial increase is desired it is necessary to add one or more zones.

Closing the Gaps Between Boards. For best operation there should be little or no space between the boards as they pass through the drier. In most installations this is not so, which causes loss in drier capacity and overdried ends.

It is well worth while to study the feed section and to make the necessary speed adjustments so as to avoid these gaps entirely. In many cases a loss of as much as 5% has been observed.

One simple method to correct this is to change the sprocket drive ratio in the feed section so that this section will drop back to a speed slightly higher than the drier deck speed. This will permit the boards to gain on the previous boards and close the gap before entering the drier proper.

In order to get the best results from a roller drier, the quality of the operators and supervision should be high, they should be well trained and conversant with the basic principles involved. Incentive systems based on performance are both practical and of great help in improving the operation and in attracting the best grade of help. The modern drier is a fine piece of equipment and will give good service and performance if used intelligently.

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A Study of the Components of Jack Pine Groundwood White Water with Special Emphasis on the Foam Phenomenon

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The excessive foaming encountered in the grinding of green jack pine wood is well known to the paper industry. In contrast, little trouble has been experienced with seasoned pine or with spruce. As a result, the use of the green wood has been avoided as much as possible, because the presence of foam on the paper machine causes poor formation of the sheet on the wire. In the present work, synthetic white water extracts were prepared from jack pine sawdust in the laboratory under controlled conditions and the foam data (or foaming ability of the wood) were studied. A definite decrease in foaming ability occurred with the seasoning of jack pine sawdust in air, whereas storage in nitrogen prevented this decrease. The removal of resinous materials from the wood had limited effect on the foaming ability. Variations in the preparation of the extracts showed that the high temperature of the water is the primary factor in producing the foam effect. The dispersions are affected by time, temperature, various additives, and adsorption of colloidal material by sawdust or charcoal. With the aid of two types of foam fractionation columns, the foam in the hot water extracts was concentrated and the agent responsible for the foam, a "soluble lignin," was isolated. Jack pine foam concentrates also contained large amounts of an alkali-soluble "pitch" but only a small amount of this pitch was found in spruce foam. Summative analyses of the hot and cold water extracts showed that three main fractions were present: carbohydrate (an arabogalactan), lignin, and pitch. The last two fractions were colloidally dispersed. The carbohydrate did not contribute to the foam phenomenon. Spruce white waters contained almost as much material as the jack pine. Continued hot water extraction of jack pine sawdust removed about 18% of the weight of the wood, mostly as carbohydrate material. A reconstitution of the white water system was attempted. The lignin, whether isolated from jack pine or spruce foam or from the defoamed liquids, gave aqueous dispersions with similar foam data. There is an optimum concentration at which maximum foam stability of the lignin is obtained. The effect of pitch on the stability of the foam could not be definitely established.

Sawdust, cut and screened to 20 to 36 mesh, was used as the raw material. Coarser cuts gave poor results and finer cuts showed no advantage over the 20 to 36 size. Ten-gram samples (dry basis) were extracted with 500 ml. of boiling distilled water for 16 hr. in 1000-ml. flasks fitted with reflux condensers and heated in a wax bath at 110 to 120°C. The mixture was then filtered hot through coarse filter paper and the cloudy yellow filtrate cooled to 20°C. The time and temperature of heating were selected on the basis of convenience of operation. Actually, in most groundwood mills, a temperature of approximately 70°C. is maintained in the grinders, and the time is much shorter than that given above. However, the grinding action provides a groundwood much finer than sawdust, and, in a closed white-water system in the mill, the water is constantly recirculated, so that a certain "buildup" of hot water extractives occurs.

The foaming properties of the extracts were measured by the method of Ross and Miles (*2*). A definite quantity of liquid is allowed to fall from a height through an orifice; during this fall it breaks into small droplets before impinging on the liquid below. In this way a large quantity of the liquid is thoroughly aerated. The height of foam produced is measured during a period of 5 min. Observations of the foam after longer periods of time may show differences not apparent at the shorter time. On the paper machine, a small amount of persistent foam is produced constantly by the agitation of the stock on the wire. This type of foam may or may not be of the same type as that developed by the present foam meter. Nevertheless, it has been shown in the laboratory that the foam behavior of the extracts from various woods can be correlated roughly with the behavior of the various white waters in the mill (*3*).

Table I. Reproducibility of the Foaming Ability of Green Jack Pine

Sample		Foam height in mm. at 20°C. 30 sec.	120 sec.	300 sec.
I		140	130	125
		140	130	130
		140	130	125
		140	130	125
		140	135	130
		140	135	130
	Av.	140	132	128
II		95	80	25
		105	45	10
		95	80	20
		95	80	60
		95	70	15
		95	70	15
	Av.	93	71	18

In order to determine the precision of the method, foam measurements were made on several extracts from the same sawdust. Data for extracts obtained from two different samples of jack pine sawdust are given in Table I. The horizontal rows of data under each wood represent separate extracts. Repeated foam measurements on the same liquid sample were

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unreliable, probably because of absorption on the glass walls of the foam meter. Therefore, single measurements were made on several extracts. In the case of a relatively unstable foam, the precision of the data is much less. The variation in the precision of the data from log to log or from portions of a log was great. In an attempt to minimize this, sections were always cut from several logs and the resultant sawdust was thoroughly mixed.

RELATION BETWEEN SEASONING OF JACK PINE AND FOAMING ABILITY

General experience in groundwood mills indicates that seasoned jack pine will not give the foam trouble encountered with the unseasoned wood. This seasoning effect has been shown very definitely in the laboratory (Table II). Freshly cut sawdust undergoes a slight decrease in foaming ability on storage for two weeks; after storage in air for 1 yr., a very great decrease was observed.

Table II. Effect of Seasoning Jack Pine on Its Foaming Ability

Form of wood when seasoned	*Time*	*Samples*	*Foam height in mm. at 20°C. 30 sec.*	*120 sec.*	*300 sec.*
Sawdust in air	0	6	140	133	128
	2 wk.	6	145	129	122
Sawdust in air	0	2	120	105	92
	1 yr.	2	75	30	7
Log—ends painted and bark intact	0	2	120	105	92
	1 yr.	4	140	117	108
	2 yr.	6	140	132	128

The seasoning effect seems to be due to two factors: the presence of oxygen (in the air) and the removal of moisture. Logs with the bark intact and ends painted season very slowly.

The accelerated effect of oxygen can be shown in the laboratory. Several samples of sawdust (freshly cut from unseasoned jack pine logs) were placed in glass containers and the latter were evacuated and then filled with nitrogen or oxygen. The nitrogen was freed of oxygen by passage over hot copper gauze (4). The samples were then stored for 210 days at room temperature. The oxygen atmosphere effected a much greater decrease in foam stability than did the nitrogen (Fig. 1). This effect was also greater for air-dry samples (7% moisture) than for moist samples (38 to 44% moisture), possibly because less air was displaced by the nitrogen from the moist samples. When the several flasks containing an oxygen atmosphere were opened, a slight vacuum was noted, apparently produced by a consumption of the gas by the wood in the seasoning process. No such effect was noted with nitrogen.

VARIATIONS IN PREPARATION OF THE SYNTHETIC WHITE WATERS

The synthetic hot water extracts from green jack pine sawdust are generally cloudy, yellow colloidal solutions. In contrast, seasoned jack pine and spruce extracts are clear. The foam stability of samples decreased with time, a greater effect being shown at 20°C. than at 5°C.; mold growth seemed to decrease the foam stability.

The effect of temperature (Fig. 2) is reversible, in that a solution, after showing a low foam stability at a high temperature, will show an increased stability if the temperature is lowered.

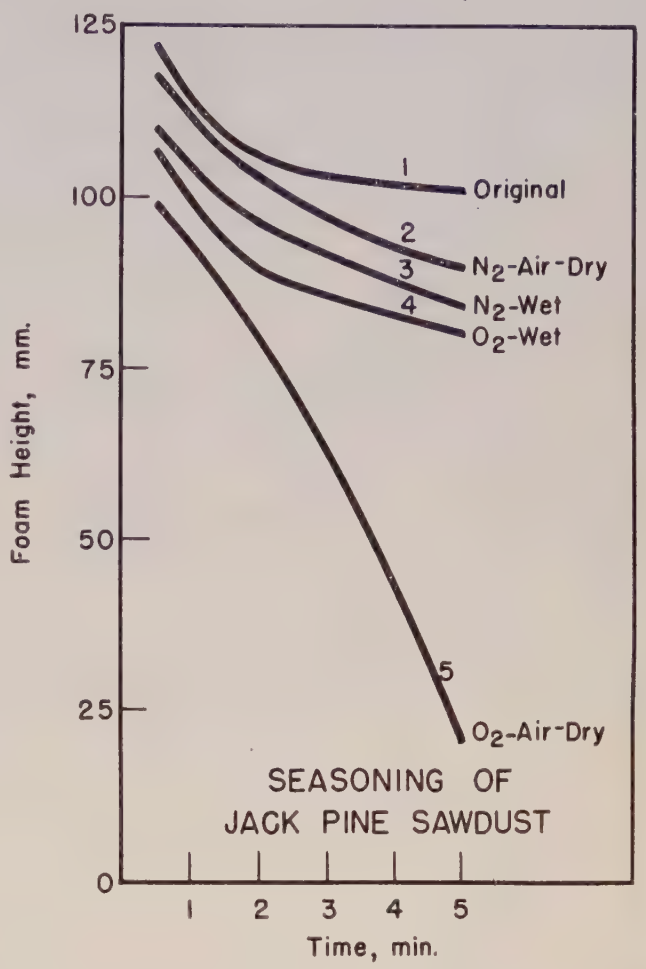

Fig. 1. Seasoning of jack pine sawdust. The wet samples contained 38 to 44% H_2O, the dry samples 7% H_2O. The wet oxygen sample was sterilized 15 min. to prevent any rot or mold forming during the storage period of 210 days at room temperature

The constituents responsible for the foam are apparently either dispersed in hot water or formed by the action of the hot water on the wood (Fig. 3). The slight foaming of cold water extracts may be increased by heating after filtration. Agitation seems to be an important factor, as heating of sawdust with water in an oven at 97°C. without stirring produced a much weaker foam than that obtained by refluxing at 100°C. (The cold water extracts, in contrast, were prepared with stirring.)

The cold water extracts foam weakly and are clear white solutions. This would indicate a much smaller removal of colloidal material at the lower temperature. The foaming ability of such sawdust, after cold water extraction, seems unaffected. In contrast, repeated extractions with hot water show a very decided drop in the foaming ability of the resultant wood (Fig. 4). Each of the five successive extracts was made by the standard method; the last two show a foaming action almost as weak as a cold water extract. The amount

of foaming agent is limited and is rapidly removed by hot water extraction.

Normally, the hot water extracts are filtered hot. If the mixture of hot water and sawdust is allowed to

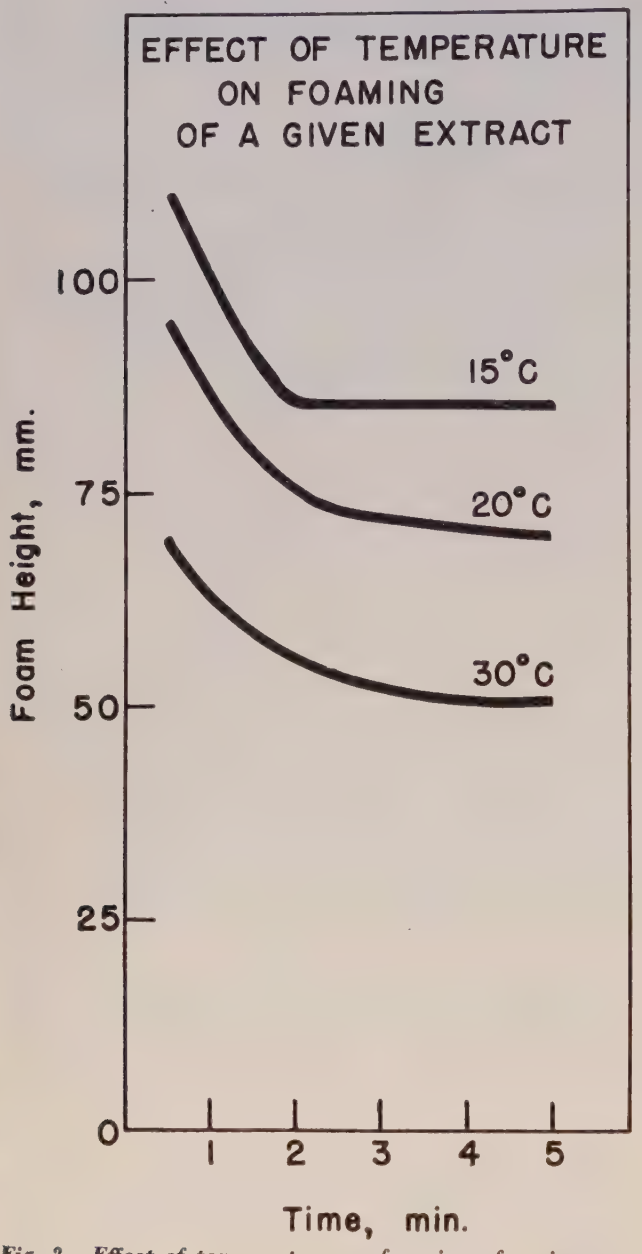

Fig. 2. Effect of temperature on foaming of a given extract

cool and then filtered, the filtrate will have a much lower foam stability, apparently because of the greater adsorptive effect of sawdust at the lower temperature. This effect can also be shown by subjecting a hot water extract, previously filtered and of known foam data, to contact with sawdust at room temperature (Fig. 5). The effect is proportional to the amount of sawdust present. Seasoned sawdust showed a greater effect than did the unseasoned wood. As an alternative explanation to adsorption, it is possible that some ingredient in the seasoned sawdust may act as a foam depressant.

Activated charcoal showed a much greater effect. The addition of 1 gram of charcoal to 1 liter of green jack pine hot water extract gave a clear filtrate with absolutely no foaming ability.

Addition of small amounts of papermakers' alum $[Al_2(SO_4)_3 \cdot 18H_2O]$ to the water before extraction of the sawdust showed little effect. Increasing concentrations produced a depressing effect on the foam (Table III). Additions of alum to the extracts of unseasoned jack pine *after* preparation had little effect, but the foam stability of seasoned pine extracts was greatly increased.

A very great increase in foam stability was caused by the addition of 50 mg. sodium aluminate per liter of extract; above this value the foam stability decreased (Fig. 6). At a concentration of 250 mg. per liter, an alkaline yellow-green solution was formed.

The filtered hot water extracts are normally acid, with a pH of 3 to 4. Addition of 2 grams of concentrated sulphuric acid to 500 ml. of water before the refluxing period reduced the foaming ability to a negligible value.

Removal of the resinous products of the wood by benzene-ethanol extraction caused a very definite drop in the subsequent foaming ability (Table III). Ether extraction produced only a slight effect. These effects were not always reproducible.

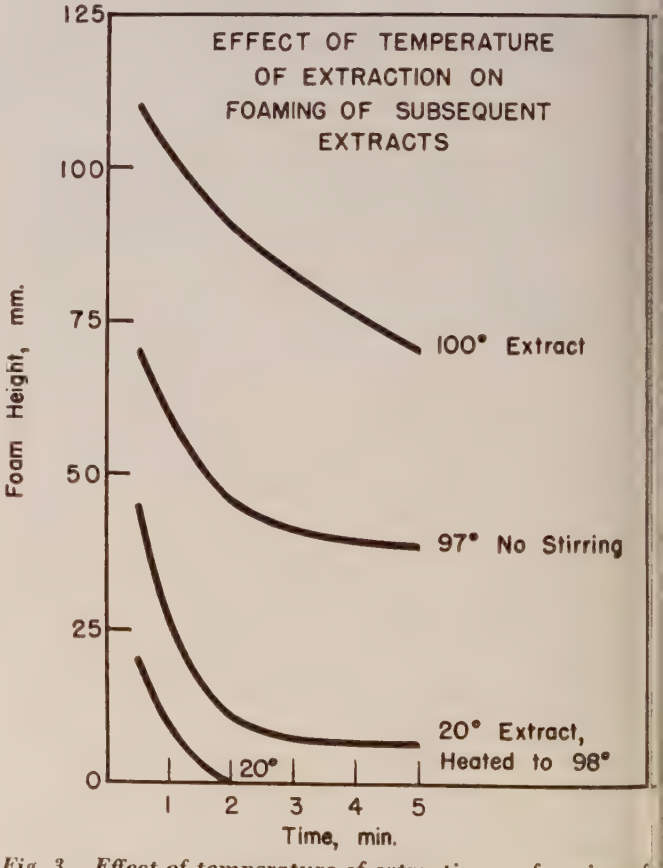

Fig. 3. Effect of temperature of extraction on forming of subsequent extracts

Dilution with organic solvents depressed the foam. The effect of acetone was greater than that of ethanol. Ether vapor will temporarily break the foam head on the liquid. Octyl alcohol in a dilution of 10 p.p.m. and butyl phosphate, both applied as acetone solutions,

produced a limited decrease. A mixture of linseed oil, kerosene, and a sulphonated oil (*5*), also applied in acetone solution, was the most effective agent. In concentrations of 2 p.p.m., it caused the foam to drop to zero stability for a 2-min. reading on the foam meter.

Table III. Effect of Removal of Extractives on Foaming Ability of Green Jack Pine Sawdust

Description	No. samples	Foam height in mm. at 20° C. 30 sec.	120 sec.	300 sec.
Unextracted	2	115	105	90
Ether-extracted	2	112	92	80
Benzene-ethanol extracted, then chloroform extracted	2	110	90	70
Unextracted	6	146	128	122
Benzene-ethanol extracted	4	85	74	38

For mill applications, still smaller amounts might be sufficient for the white water, since it may be desirable

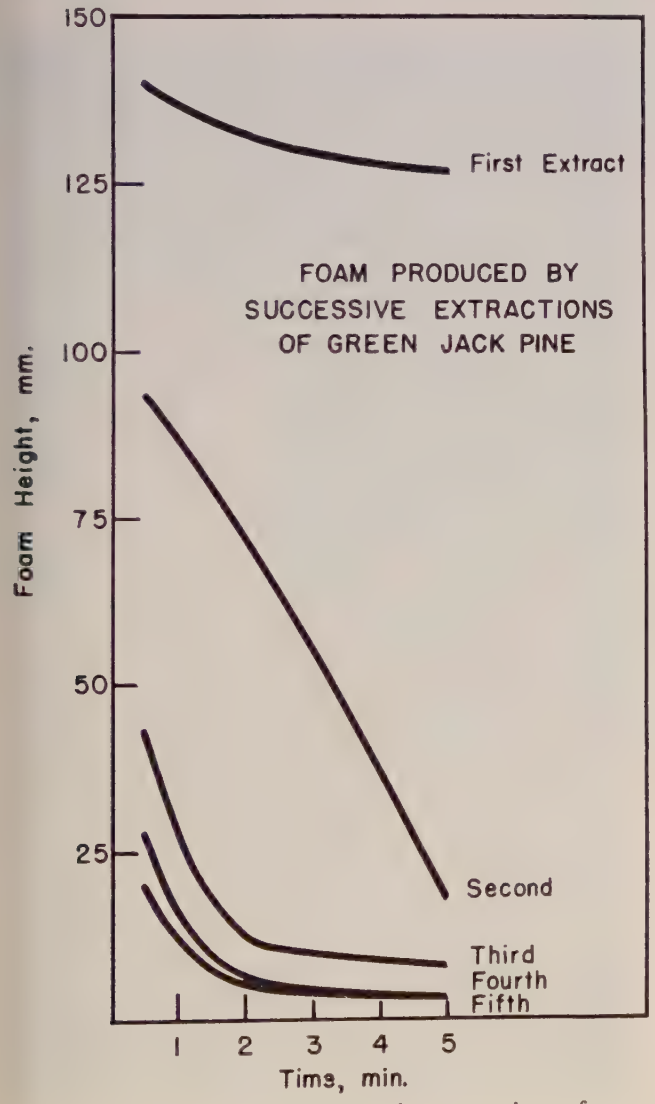

Fig. 4. Foam produced by successive extractions of green jack pine

to maintain the foam condition in the mill at a certain level and not eliminate it entirely.

In this work jack pine has been the main wood used. A few experiments with unseasoned spruce gave the same degree of foaming ability data as thoroughly seasoned jack pine.

THE TECHNIQUE OF FOAM FRACTIONATION

The theory of foam fractionation or foamation will be discussed only briefly. For more details the reader

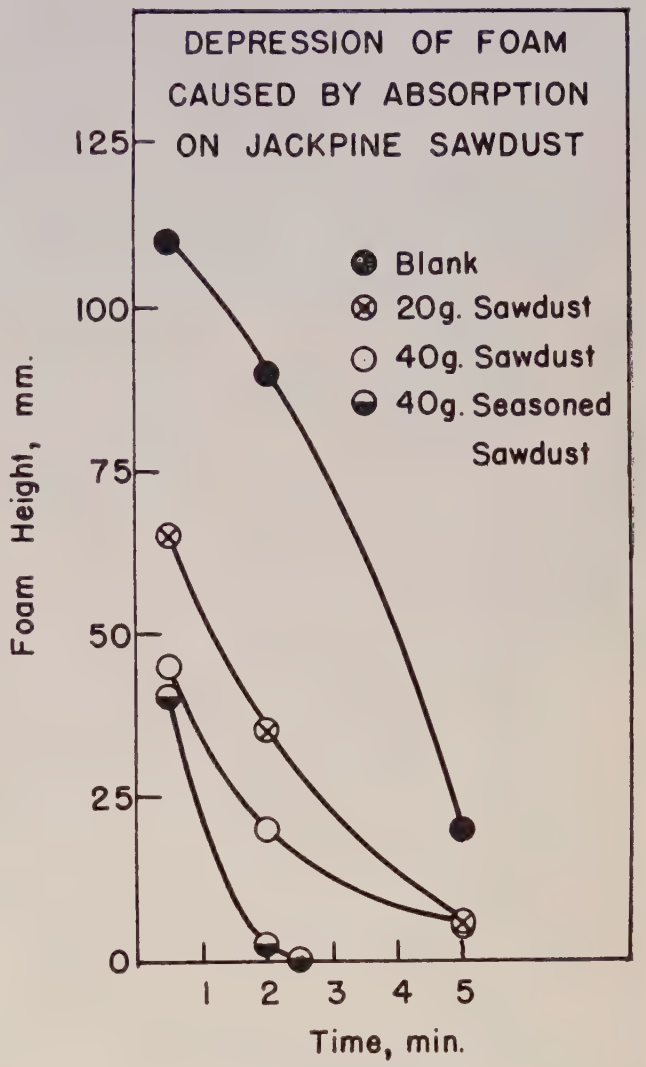

Fig. 5. Depression of foam caused by absorption on jack pine sawdust

referred to the literature (*6*). A liquid *O* will foam strongly in the presence of a colloidally dispersed surface-active agent *X*, which will be more concentrated on the surface than in the bulk of the liquid. Since the surface is normally small in relation to the volume of the liquid, only a small amount of *X* is present on this surface.

Subjecting a column of liquid in a vertical glass cylinder to flow of air or nitrogen from a diffuser at the bottom of the tube will create foam on the top of the liquid, with a very large surface in relation to the actual weight of liquid present. If this foam is created slowly and removed slowly, the excess liquid will drain from the foam and a maximum concentration of the surface-active material will be achieved. Liquid *O* will be then separated into a foam and a weakly foaming residual liquid. The foam will slowly collapse to a concentrated dispersion containing a large amount of *X*.

Foam Columns

In this work two types of columns have been used. A large "unpacked" column (Figs. 7 to 9), similar to those mentioned in the literature, was used for the fractionation of large volumes. A smaller "packed" column, with a capacity of only 3 liters of liquid but of much greater efficiency, was also used.

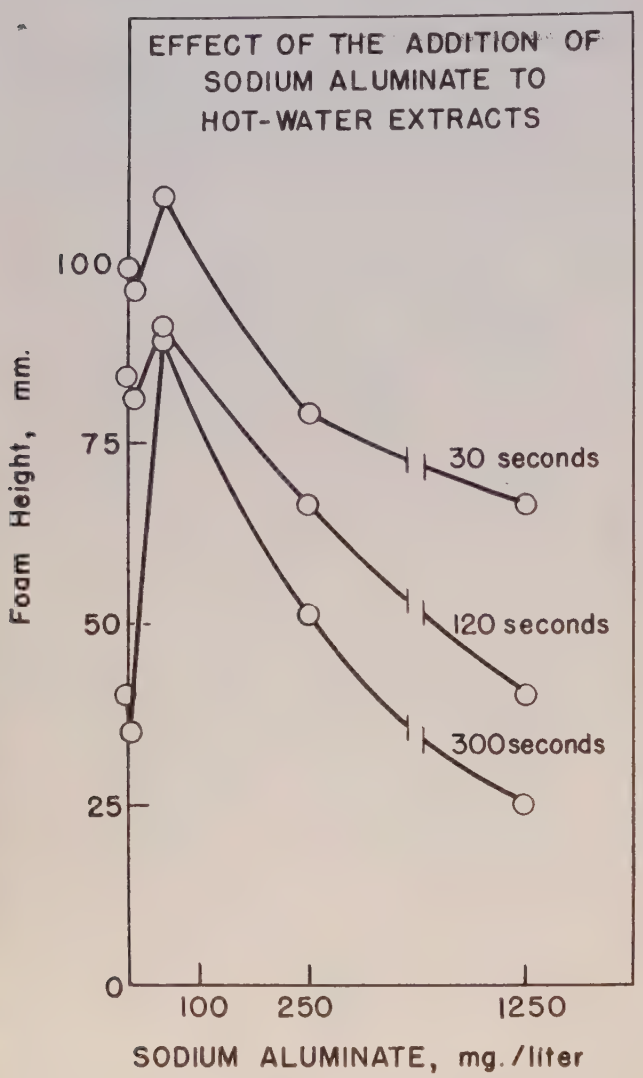

Fig. 6. Effect of the addition of sodium aluminate to hot-water extracts

In a foam column a constant draining of liquid from the foam is always observed. The more concentrated foam rises in the column and the more weakly foaming liquid drains down. The downward movement is hampered to a certain extent by the upward air flow and, as a result, the efficiency of the fractionation is impeded. To facilitate this draining action, Ostwald and Siehr designed a "circulating" type of apparatus. The foam was collected in a funnel outside the column and the liquid, formed by collapse of the foam, was returned to the bottom of the foam column. In this manner continuous circulation (a sort of reflux action) resulted and a "dry" foam was produced.

This apparatus could not be used in the present work since the collected foam did not collapse quickly enough to allow recirculation in the column. Hence, a new or "packed" column was developed, in which a more violent refluxing action was obtained by passing the foam through a series of wire screen cones arranged vertically in a column. The effect of a wire gauze in breaking foam has been used in the paper industry (7) as one method of handling foam in mill operations.

The foam fractionation procedure gives two main fractions, the foam concentrate or foamate, and a residual weakly foaming or defoamed liquid. In the case of an unpacked column, the foamate may represent 2 to 10% of the total liquid. With a packed column, the concentrate will be relatively dry, containing only 0.1 to 0.50% of the total volume of liquid.

This is shown in experiments 1 and 2 in Table IV. The colloidal liquid still has an appreciable amount of foaming agent present. If this liquid is foamed quite strongly, in contrast to the slower initial fractionation, a relatively large amount of a dilute foam concentrate (fraction 2 in experiments 3 and 4) is obtained, and the residual liquid (fraction 3) will show practically no foaming tendency. The total process might be summed up as follows: 0.1 to 10% concentrated foam, 10 to 80% dilute foam, and 15 to 90% very weak foam.

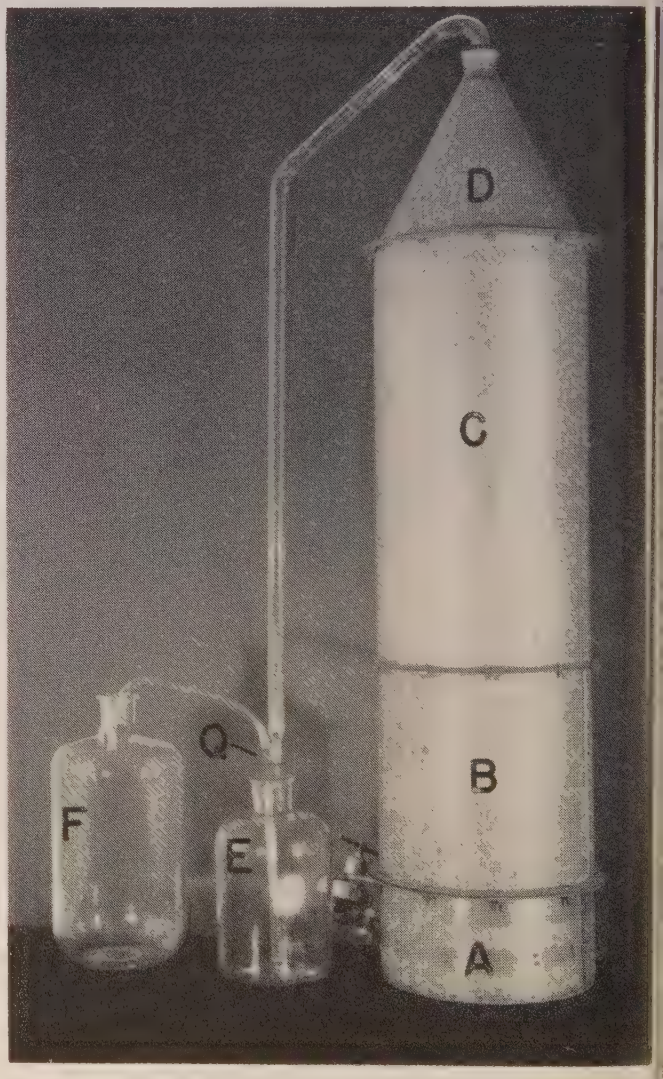

Fig. 7. Foam fractionation column

The process of removing a relatively large middle fraction has been called "defoaming." Although it is inefficient as a method of foam concentration, it is effective in the production of a nonfoaming or "de-

Table IV. Foam Fractionation as Shown by Foam Data

Expt.	No.	Fraction volume, cc.	Packed column	Time, min.	Foam height in mm. at 20°C. 0.5 min.	2 min.	5 min.
1	0	3000	...	0	95	80	70
	1	80	No	30	...	...	...
	2	2920	No	30	15	5	0
2	0	3000	...	0	80	65	20
	1	5	Yes	70	...	...	
	2	2995	Yes	70	10	0	
3	0	2800	...	0	145	129	114
	1	5	Yes	60	...	...	...
	2	450	No	60	25	15	15
	3	2350	No	60	15	1	0
4	0	3150	...	0	93	71	17
	1	5	Yes	40	...		
	2	350	No	60	...		
	3	2800	No	60	5	0	

Note: The first foam fraction obtained with the packed column contains very little water and thus has no foaming tendency. The fractionations in experiments 3 and 4 were carried out in two stages, first with a packed column, and then with an unpacked column.

foamed" liquid for the purposes of analysis. The amount of foaming agent can be estimated indirectly by a comparison of the summative analyses for the various components in the original liquid and in the thoroughly defoamed liquid.

Operation of the Unpacked Foam Column

Figure 7 shows the foam column which is composed of four metal sections: B and C are cylinders, 12 and 24 in. high, flanged at each end. D is a cone with a small upper opening which is connected by a No. 11 rubber stopper and a glass tube to collection bottles E and F.

Section A (Fig. 8) is equipped with a false bottom and a circular porous disk (G) made of Norton "Fine Porous Medium," sealed with caulking around the edges and a coating of asphalt. Compressed air is introduced below G through tubing N into a reduction

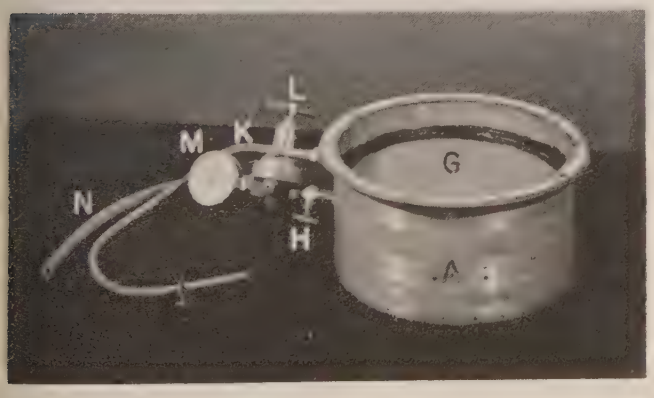

Fig. 8. Diffuser for foam column

valve L and a needle valve H. Outlet K above the disk drains the liquid from the assembled column.

Figure 9 shows the four combinations that can be made of the column by combining and interchanging sections B and C.

In actual operation, the tower is assembled to its maximum height and 24 liters of liquid are added, filling the space above the false bottom to a height of 13 in. L is set at 18 to 22 lb. pressure, and valve H is opened

Fig. 9. Foam height in the fractionation column

gradually to allow air to bubble through the liquid. In 5 min. a stream of foam will issue from the top of D. H is then carefully closed so that the foam flows from D at a rate of about 1 ft. a second. When bottle F is filled with foam, stopper Q in the intermediate bottle E is removed, allowing foam to accumulate in E. F is replaced with an empty bottle and Q is replaced.

As the foam flow from D decreases, H is gradually opened to keep the foam flow constant. Finally, when no more foam issues from D, the column is shortened and the operation is repeated. In the present work, the liquids were foamed at 36, 12, and 4-in. heights, as shown in Fig. 9. The foam collected at the lower heights was more dilute and, therefore, was removed more slowly. The more slowly the process is carried out, the more thorough is the separation. It was necessary to add 9 liters of distilled water to the column for the 4-in. height.

The combined foam fractions collapsed over a period of 2 to 3 hr. to a liquid, usually an opaque colloidal dispersion. The contrast between the original extract and the residual liquid is remarkable. In the case of jack pine, the original extract was a cloudy yellow, the residual liquid was very clear, and the liquid from the collapsed foam was a dark chocolate brown.

The colloidal material in the foam concentrate can be partly removed in a Sharples supercentrifuge at 25,000 r.p.m. The liquid is fed through repeatedly until no further clarification is observed; the final liquid is a cloudy yellow, resembling the original extract. The bulk of the separated colloidal material is scraped from the centrifuge rotor with a spatula and the remainder is washed out with a little dioxane-ethanol (4–1).

The clarified foam concentrate still foams strongly and, on further concentration in the foam column, a smaller crop of colloidal material is obtained. The concentration is not carried any further.

The actual time required for foam concentration is 6 hr. Only 3 hr. are needed for foaming the richer fractions but the fractionation at the 4-in. height has to be run slowly to avoid too dilute a fraction. Storage of the

liquid concentrate at 5°C. is recommended to prevent mold growth.

Operation of the Packed Foam Column

The column is a 36-in. length of 4-in. I.D. commercial Pyrex pipe (Figs. 10 to 12), flanged at each end, the lower end being drawn to a 3-in. I.D. A conical cap with a 14-mm. tubulation is secured to the top of the column by metal flanges, the lower of which suspends the complete assembly from the wooden stand. This suspension avoids putting weight on the fragile diffuser, which is made of fritted Pyrex glass of medium porosity, $^1/_4$ in. thick and 4 in. in diameter, with the outer edge fused. It is secured in a rubber gasket assembly (Fig. 13); gaskets A, B, and C are cemented together with rubber cement under pressure; the diffuser is then fitted in and gasket D is cemented on top with mild pressure. The assembly is then mounted between the main pipe and a lower cap with a 9-mm. I.D. side tubulation. Air or nitrogen is introduced through a reducing valve to the diffuser and into the column.

The column is packed with cones made of 14 and 60-mesh bronze screen, soldered to 3-in. lengths of $^3/_8$-in. brass rod which is threaded at the ends so that various units can be assembled. A 12-in. length of rod threaded at the lower end serves as a handle to push the cone assembly into the column and to remove it. Most of the units are made with two 14-mesh cones but one has four 14-mesh cones. The two uppermost cones are formed of 14-mesh screen with an outside layer of 60-mesh

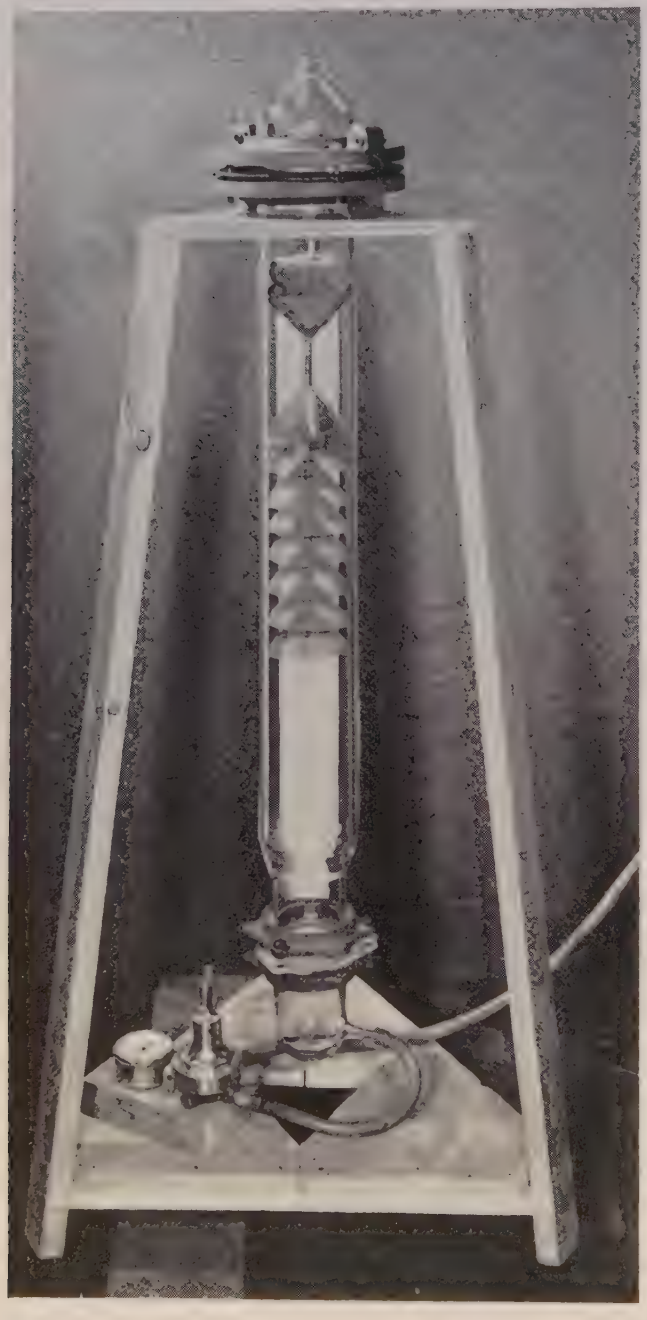

Fig. 10. Foam-fractionation column with packing of upright cones

Fig. 11. Foam-fractionation column showing reflux action of upright cones

screen cut away in a truncated form about 1 in. from the apex to allow better drainage.

A cone seems to be the best geometrical form for the screen packing, since the liquid is guided diagonally away from the air flow and foam (Fig. 14). Inverted cones (with apex down) cause the liquid L_2 to drain toward the center of the column; with upright cones the liquid drains toward the glass walls. The upright cones are more effective in breaking the foam and can be used in concentrated solutions, but the inverted cones allow

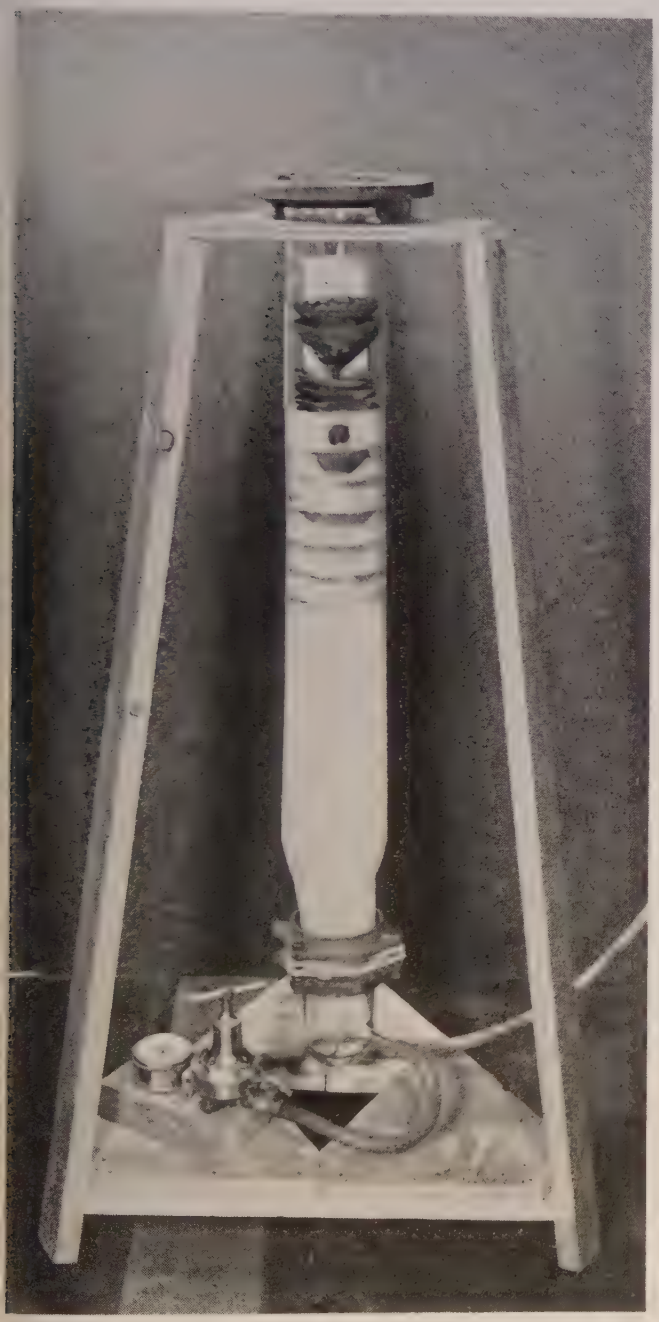

Fig. 12. Foam-fractionation column showing reflux action of inverted cones

better drainage. In both cases the foam (F_2) passing through the screen is more concentrated than the original foam (F_1).

In all cases the cones were cut to a snug fit against the glass walls. Although the use of air seems to produce no oxidation of the foamate, a corrosive effect on the bronze cones has been noticed. The residual liquid was colored a light green and the solids in this liquid contained an appreciable amount of ash on ignition. This effect was not noted with nitrogen.

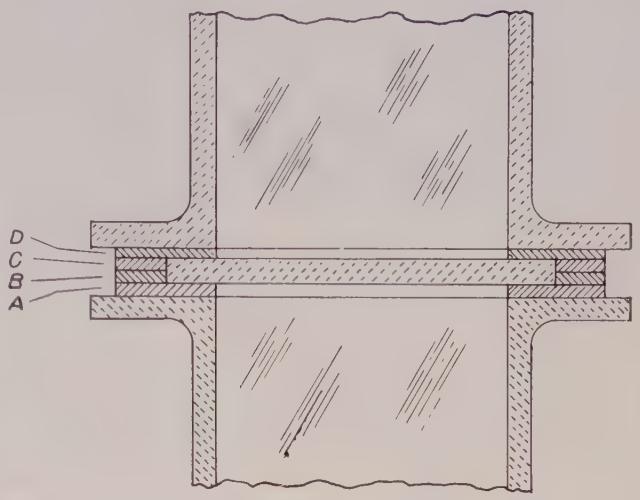

Fig. 13. Fastenings of diffuser into columns A, B, C, and D are rubber gaskets, each 1/8 in. thick

After 3000 ml. of liquid had been introduced into the column, the air flow is started at a very slow rate and gradually increased. The foam was never allowed to rise above the 12th cone. The flow rate and volume of air were measured with a wet-test flowmeter connected to the upper cap. It was difficult to maintain a slow initial flow without the aid of such a meter.

Table V. Sample Flowsheet of Foamation in Packed Column

Time, min.	*Flow, cu. ft.*	*Rate of flow, cu. ft./hr.*	*Pressure on sintered disk, lb./sq. in.*	*Cone arrangement and remarks*[a]	*Foam height*
0	0.0	0.5	3	Upright cones as in Fig. 11	...
15	0.1	0.4	3	.....	10
25	...	1.0	3	Flow too fast	12
35	...	0.8	3	Flow too fast	10
50	...	0.4	3	Foam drying on top cones	10–11
60	0.5	1.0	4	.....	7
80	...	1.3	4	.....	10
90	...	2.0	6	.....	10
105	...	6.0	6	.....	...
115	3.5	13.0	6	.....	10
115	3.5	2.0	7	Inverted cones as in Fig. 12	...
140	4.5	6.5	6	.....	9
160	10.1	11.5	6.5	Foam collapses in 72 seconds	6
350	49.7	7.0	6.0	Foam collapses in 53 seconds	6

[a] The foam height refers to the highest cone reached by the foam. The time of foam collapse is measured after the air flow is suddenly cut off. This time gives a rough idea of the foam stability of the remaining liquid.

A flowsheet of a typical two-stage foamation is given in Table V. The cones are arranged initially in an upright position, as shown in Fig. 10. As the foam rises through the cones, it becomes concentrated and "drier." This can be seen in Fig. 11, which shows the 50-min.

stage on the flowsheet. The clear spaces above cones 1–3 are filled with liquid, showing the poor drainage effect of the upright cones. Above the 6th cone the foam is becoming dry, but the series of cones very close to-

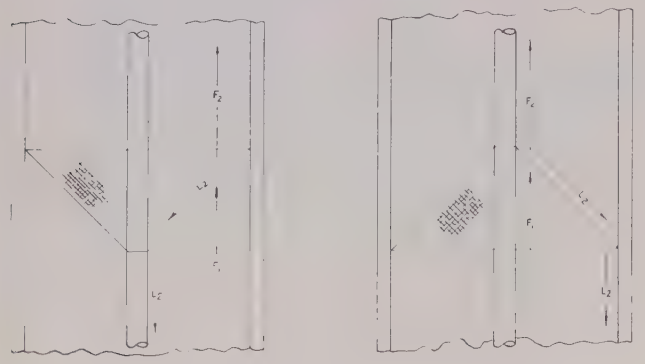

Fig. 14. Drainage of collapsed foam on wire screen cones

F_1 = original foam, F_2 = foam concentrated by passage through the cone, and L_2 = the collapsed foam or liquid draining down in the column

gether breaks it up again. Finally, above cone 10 a very dry foam is formed. The foam level will soon drop to the region of cones 7–10. The airflow is then increased, until at 115 min. no further foam deposits on the cones. The complete packing is then removed and washed with ethanol. This is best done by carefully unscrewing each unit and immersing it in a beaker of solvent.

The second stage is shown in Fig. 12, with the cones assembled in an inverted position (at the 160-min. interval). The inverted cones give better drainage than do the upright ones. The foam above cone 6 is definitely drying, as can be seen from the large hole in the center of the foam area.

With either cone arrangement the foam often dried on the cones to a light yellow fluffy powder. Sometimes it was obtained in a relatively wet condition as a scum containing up to 80% water. Undoubtedly some of the drying action may be attributed to evaporation, as well as to downward drainage. Since the air should be saturated with water after passage through the column of liquid, evaporation should be small.

The results with this column are very satisfactory, as the amount of lignin and pitch isolated is three to four times that obtained in an ordinary column. Also, the foam is almost dry. In contrast, the collapsed foam from the unpacked column has a maximum concentration of 0.1% surface-active solids (see Table VI).

THE ISOLATION OF THE ACTIVE FOAMING AGENT FROM HOT WATER EXTRACTS OF JACK PINE AND SPRUCE SAWDUST

Six batches of unseasoned pine sawdust (each 540 grams) were extracted by stirring for 16 hr. with 27 liters of water at 100°C. under reflux. The 24 liters of filtered extract from each batch were a cloudy yellow, even after centrifugation or filtration through filter paper.

If the fractionations were carried out carefully at 10 to 20°C., the total volume of foam concentrate for each batch could be kept below 2000 cc. Often the fractionation was hurried and the volumes were larger (3300 cc., comprising 1300, 1100, and 900 cc., respectively, for column heights of 36, 12, and 4 in.). The reason for the haste was a desire to complete the fractionation the same day that the hot extract was filtered. It was more convenient to store the foam concentrate (rather than a larger volume of the original extract) overnight in the icebox to avoid bacterial contamination.

Table VI. Yields of Surface-Active Agent Collected in Packed Column[a]

Expt.	*Remarks*	*Concentration of solids in foamate, %*	*Yield of solids isolated, %*
265	No packing	0.04–0.07	0.28
325	6 cones	About 20	0.67
326	9 cones	About 20	0.58
327	10 cones	About 20	0.68
328	10 cones, 2 stages	About 20	1.04

[a] The yields given are of "soluble lignin" and ether-soluble "pitch." The product in the first experiment was the ethanol-soluble material obtained by centrifuging the collapsed foam. In the other cases, the yield was the ethanol-soluble portion of the "dry" foam collected on the cones. The yields are based on the amount of wood (20 grams per liter) used to prepare the aqueous dispersions.

The six foam concentrates, after centrifugation, were combined and diluted to 5 volumes with water. Further fractionation gave a second foam concentrate of 4 liters. This was centrifuged and the filtrate discarded.

The combined dark brown precipitates from the two foam concentrates were stirred in dioxane-ethanol (4–1). The black residue was separated from the red solution, washed with more solvent until the latter was colorless, and dried at 25°C. and 5 mm.

The red solution was concentrated to a small volume and poured into an excess of absolute ethyl ether, giving a light tan precipitate. The mother liquor was concentrated further and three more precipitates collected. Two of these were dark brown and were combined with the first fraction. The third was a light tan and was investigated separately.

The final filtrate was concentrated on a steam bath to a viscous red sirup, which was dissolved in 20 ml. of benzene and the solution poured into 400 ml. of ligroin (b. 60–100°C.). A chocolate-brown precipitate formed, which was very resinous and stuck to the glass walls of the beaker and to the stirrer. This material was washed with fresh ligroin and dried at 25°C. and 5 mm. to a slightly sticky powder with a caramel odor. Over a period of several weeks it gradually reverted to a sticky sirup.

The amounts and methoxyl contents of the several fractions are given in Table VII. The main fraction seems to be a rather pure "soluble" or native lignin. It gives a positive phloroglucinol test. The methoxyl content of 15.1% is close to the value of 14.8% obtained by Brauns (*8*) for lignin isolated from black spruce. The solubility is also similar to that of Brauns' product. A sample of the latter, dispersed in water (see details below), foamed strongly. Therefore, it is possible that the "soluble lignin" extracted from wood by hot water is similar to the native lignin of Brauns extracted by ethanol at 25°C.

The second ether-insoluble fraction seems to be a slightly impure lignin. The nature of the dark gray insoluble residue with 4.6% methoxyl is not known. The low methoxyl content may be due to some "insoluble" lignin which is formed from the soluble type during the extraction of the sawdust with hot water. This fraction also gives a positive phloroglucinol test.

Table VII. Analysis of Components of Unseasoned Jack Pine Foam Concentrate

Fraction	Yield, g.	Yield, % of wood	Methoxyl, %	Solubility in: Dioxane-ethanol	Ethyl ether	Ligroin
1	1.02	0.03	4.6	Insol.	Insol.	Insol.
2	3.62	0.11	15.1	Sol.	Insol.	Insol.
3	1.80	0.06	13.1	Sol.	Insol.	Insol.
4	3.96	0.12	5.4	Sol.	Sol.	Insol.
	Total yield, 0.32					

The slightly sticky brown powder seems to be a "pitch" or resin. It is soluble in many organic solvents and has considerable tackiness. A qualitative test with bromine showed unsaturation. The substance is soluble in alkali and is reprecipitated by acid. It is also soluble in aqueous sodium bicarbonate and probably contains carboxylic acid groups. Since it has no surface activity in water, it is adsorbed in the foam

Table VIII. Analysis of Components of Black Spruce Foam Concentrate

Fraction	Yield, g.	Yield, % of wood	Methoxyl, %	Solubility in: Dioxane-ethanol	Ethyl ether	Ligroin
1	0.42	0.03	5.2	Insol.	Insol.	Insol.
2	1.88	0.12	15.3	Sol.	Insol.	Insol.
3	0.16	0.01	...	Sol.	Insol.	Insol.
	Total yield, 0.16					

formed by the lignin dispersion. The methoxyl content is too low for a lignin derivative and the phloroglucinol test is negative.

Three batches of black spruce sawdust (540 grams each) were extracted with hot water by the method used above. The filtrates were rather clear instead of being a cloudy yellow, as in the case of jack pine.

Table IX. Summative Analysis of Synthetic Black Spruce White Waters

Sample	Carbohydrate, %	Lignin, %	Pitch, %	Lignin + pitch, %	Total, %
Original extract	2.35	1.87	0.77	2.64	4.99
Defoamed extract	2.63	0.89	0.45	1.34	3.93
Removed by foam (calcd.)	−0.28	0.98	0.32	1.30	1.06
Original extract	2.32	1.47	1.46	2.93	5.25
Defoamed extract	2.37	0.76	0.71	1.47	3.84
Removed by foam (calcd.)	−0.05	0.71	0.75	1.46	1.41

The foam concentrations were carried out twice as above, but, because of the less stable foam at column heights of 12 and 4 in., the volumes of foam concentrate were 300 to 400 and 1500 cc., respectively.

The details of the fractions are listed in Table VIII. Apparently the bulk of the foam concentrate consisted of "soluble" lignin. The absence of pitch in the spruce fraction is a remarkable difference from the jack pine foam. However, it should be recalled that the yield of foam concentrate per unit weight of wood by the use of the large unpacked column is low and that, in the above work, only the water-insoluble part of the collapsed foam concentrate was investigated. It is shown in Table IX, by a process of "defoaming," that an appreciable amount of pitch is concentrated in the spruce foam.

Only a few experiments have been carried out on spruce aqueous extracts with the "packed" column. In one case the amounts of lignin and pitch obtained were 0.21 and 0.25%, respectively. In another case, only 0.06 and 0.09% were obtained. These experiments confirm the "defoaming" analyses mentioned above.

TECHNIQUE OF SUMMATIVE ANALYSIS

The summative analysis scheme consists essentially of the precipitation of the carbohydrate from the concentrated water solution into dioxane or ethanol, subsequent precipitation of the lignin fraction from dioxane into ether, and isolation of the nonvolatile ether-soluble residue as pitch. All three fractions are impure and a process of resolution and reprecipitation is necessary.

The original cloudy yellow hot-water extract (usually 3000 ml.) is concentrated *in vacuo* (with a little hexanol to prevent foaming) at 40 to 50°C. to about 5% of the original volume. The resulting liquid is dark brown and turbid because of gradual precipitation of the pitch and lignin. The latter constituents are redissolved when the suspension is slowly poured into a thoroughly stirred (5 to 10 volumes) mixture of 4–1 dioxane-ethanol. (Ordinary dioxane was used at this stage.) The white flocculent precipitate, composed of water-soluble carbohydrates,* is centrifuged and washed several times with dioxane-ethanol. The clear yellow-red mother liquor is concentrated to a small volume and poured into 10 volumes of absolute dioxane (distilled over sodium). The small precipitate of carbohydrate is centrifuged and washed with dioxane.

The dioxane-water solution is then concentrated to a few milliliters and the latter added to 10 volumes of absolute ether; the resultant light yellow precipitate will generally contain about 30 to 50% lignin; the remainder is carbohydrate.† This composition was determined by methoxyl analyses. Often, because of the small amounts of material being handled, or of the time element, this fraction was not purified further but was washed thoroughly with ether, dried, and weighed. Preliminary drying of the ether-moist sample is best carried out in a desiccator to prevent adsorption of water, which will convert the light powdery product into a dark red gel.

A little more lignin can be precipitated from the concentrated dioxane-ether mother liquor by addition to ether, then by addition to a 3 to 1 mixture of ether-

* An analysis of one of these samples, kindly performed by L. E. Wise, showed a 9-2-1 molar ratio of D-galactose, L-arabinose, and uronic acid.

† In one case, extraction of a thoroughly dried fraction with dioxane left an insoluble residue of crystalline L-arabinose, identified as the phenylosazone and the diphenylhydrazone.

ligroin. This last precipitate is often sticky and can be converted to a light flocculent product by reprecipitation into ether.

After the maximum amount of lignin has been removed from the dioxane solution, addition to ligroin (b. 30–60°C.) precipitates the remaining product as a red viscous oil. This is dissolved in a minimum of dioxane, transferred to a weighing bottle, partially dried on a steam bath, and then *in vacuo* at 60°. Constant weight cannot be achieved, a slightly volatile material being gradually removed. A 500-mg. sample may lose 5 mg. an hour for a period of 15 to 20 hr. Generally, the weight is taken when this loss in weight approaches a constant rate.

A few words might be said about the purity of the products and the precision of the analyses. The carbohydrate fraction contained only a little lignin. The lignin fraction, when isolated from the aqueous extracts, always contained some carbohydrate, and the pitch fraction contained some lignin. Purification of the several fractions by a reprecipitation process was quite tedious. Some of the carbohydrate fraction contained in the lignin was quite difficult to handle, being gummy when precipitated into ethanol or dioxane; it is probably mostly low molecular weight sugars, in contrast to the initial precipitate of arabogalactan. Purification of the lignin by solution in dioxane, washing with water, extraction of the lignin from aqueous suspension with solvents such as butanol, or chromatographic adsorption on Florex clay and elution with aqueous ethanol were tried. These methods were also tedious and loss of material occurred. It will be noted that the lignin obtained from the foam concentrates contained no carbohydrate and was relatively pure, judged by its methoxyl content.

In Table IX are given duplicate determinations for two hot-water extracts of black spruce sawdust. The two lignin values deviate by 20% and the pitch values by a greater amount. The total sum of lignin and pitch in each case, however, shows a difference of only 10%. The values of lignin in this case were not corrected for carbohydrate present.

In a typical paper mill grinder pit, the white water system contained about 600 mg. carbohydrate per liter, 120 mg. pitch, and 40 mg. lignin. These values increase, of course, as the white water recirculates throughout the paper mill.

HOT AND COLD WATER EXTRACTION OF UNSEASONED JACK PINE SAWDUST

The solvent action of cold water of wood falls off very rapidly, resembling the action of benzene-ethanol or of acetone (Fig. 15). In the first extraction about 1% of the wood is removed and in a second extraction only 0.1%. The action of hot water is very different (Fig. 16). The extraction continues at a fairly constant rate for about 60 hr., after which a gradual decrease is noted. It almost seems as though the action of hot water might be hydrolytic. The resulting extracts are acidic (pH 3 to 4) and the fact that 18% of the wood

Table X. Summative Analyses of Successive Hot-Water Extracts of Jack Pine Sawdust

	Components isolated (percentage based on dry wood)												*Composition of various fractions (in percentage of total components)*									
	Carbohydrates			*Lignin*				*Pitch*					*Original liquid*				*Foam*			*Defoamed Liquid*		
Hot-water extraction	*Isolated*	*Calculated present in ether-insolubles*	*Total*	*In foam (calcd.)*	*In residual non-foaming liquid*	*Total*	*% Total in foam*	*In foam (calcd.)*	*In residual non-foaming liquid*	*Total*	*% Total in foam*	*Water-insoluble, dioxane-insoluble portion in foam*	*Total all components*	*Carbohydrates*	*Lignin*	*Pitch*	*Water-insoluble, dioxane-insoluble*	*Lignin*	*Pitch*	*Water-insoluble, dioxane-insoluble*	*Carbohydrates*	*Lignin*	*Pitch*
1	3.00	0.66	3.66	0.310	0.53	0.84	37	0.370	1.18	1.55	24	0.170	6.22	59	13.0	25	5	36	44	20	68	10	22
2	2.74	0.24	2.98	0.080	0.22	0.30	27	0.135	1.04	1.18	11	0.100	4.56	65	6.6	26	2	25	43	32	70	5	25
3	1.87	0.34	2.21	0.055	0.13	0.18	31	0.110	0.84	0.95	11	0.024	3.37	65	5.3	28	1	29	58	13	69	4	27
4	1.31	0.28	1.59	0.033	0.10	0.13	25	0.077	0.64	0.72	11	0.014	2.45	65	5.4	29	0.6	27	62	11	68	4	28
5	0.89	0.14	1.03	0.016	0.07	0.09	18	0.044	0.22	0.26	17	0.008	1.39	74	6.5	19	0.5	23	65	12	78	5	17
Total	9.81	1.66	11.47	0.49	1.05	1.54		0.74	3.92	4.66		0.32	17.99										

60 grams of unextracted green sawdust were used; 1% component = 600 mg. A packed foam column was used to collect the foam concentrate. The remainder of the foam was then removed in a defoaming procedure.

The actual amount of ether-insoluble or lignin fraction isolated contained water-soluble carbohydrate. Correction was made, calculated on the methoxyl content, with the assumption that 15.3% OMe represented the carbohydrate-free fraction.

The ether-soluble or "pitch" fractions are soluble in 95% ethyl ether but insoluble in absolute ether.

aside from the benzene-ethanol extractives and cold-water solubles, has been removed shows that a profound change has taken place in the wood. Very few data are given in the literature for such effect of hot water (*9*).

The greatest amount of material removed is carbohydrate (Fig. 17 and Table X). The rate of extraction of the lignin and pitch is much less and the relative proportion of the three components seems fairly constant. This might lead one to surmise that the same reaction is affecting all three components, and that possibly a "compound," containing these three in a definite ratio, is being attacked by the hot water. Such speculation is interesting but the data given are not conclusive.

It will be noticed that, in the successive extractions of jack pine with hot water, the foaming tendency decreases with decreasing concentration of the surface-active lignin. These two sets of data are plotted in Fig. 18; a rough correlation is evident. The final foam height shows a smoother curve than does the initial foam height. However, the foaming tendency of a liquid depends not only on the concentration of the colloidal material but also on the nature of the dis-

persion. The thoroughly defoamed extracts still contain appreciable amounts of both lignin and pitch. It is not clear why only a fraction (18 to 37%) of the lignin dispersed in the water is removed by the foam.

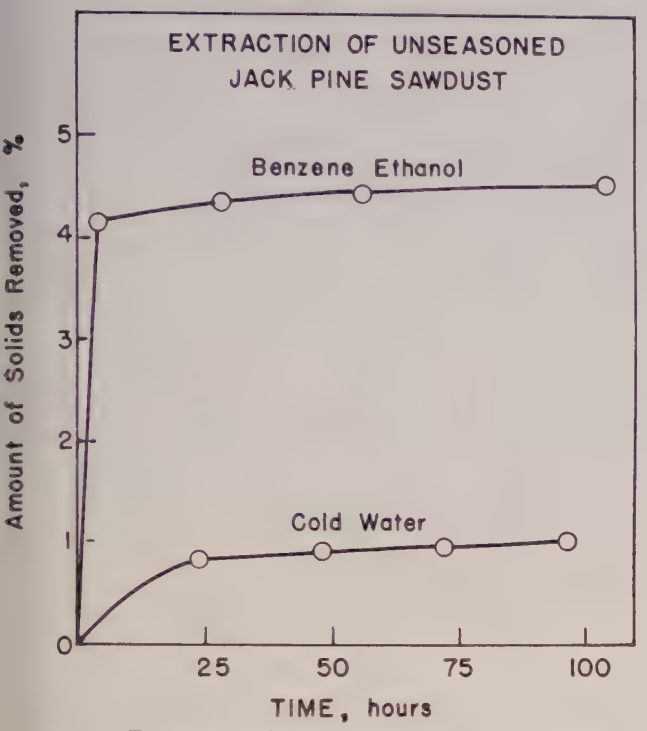

Fig. 15. Extraction of unseasoned jack pine sawdust

The lignin remaining in the wood is also surface active The pitch may have an inhibiting effect.

SYNTHETIC DISPERSIONS OF LIGNIN AND PITCH IN WATER

A general method of preparing lignin dispersions was the slow addition of a dioxane-ethanol solution of the component (10 to 100 mg. in 1 to 2 ml.) to a vigorously stirred volume (400 ml.) of water, then some wash solvent, so that the total amount of organic solvent was 4 ml. Repeated foam measurements (see Table XI) checked fairly well. The presence of the 1% organic solvent was considered a constant factor in its effect on the foam behavior. Attempts to remove it or to prepare dispersions without a solvent, as with a colloid mill, were unsuccessful. Refluxing such dispersions overnight reduced the foam data to a negligible value and "insolubilized" most of the lignin.

When a controlled rate of stirring and definite rate of addition were applied, the foam data of the several dispersions agreed roughly. However, now and then a "poor" dispersion would occur. This same effect has been noted with the hot water extracts prepared from sawdust.

The rate of addition of the two components, lignin and pitch, to the water made only a slight difference in the resulting foam data. A slightly greater stability was noted when the components were added simultaneously than when they were added separately.

The effect of the concentration of the lignin alone in water was also investigated. The initial foam height increased to a maximum at a lignin concentration of 60 mg. per 400 ml. However the final foam height at 300 sec. reached a maximum at 30 mg. per ml. and then dropped with further increase in concentration.

Table XI. Reproducibility of Synthetic Foam Dispersions

Nature of dispersion, mg. in 400 ml. water	*Measurements*	*Foam height in mm. at 20°C. 30 sec.*	*120 sec.*	*300 sec.*
13.1 mg. green jack pine lignin	5	79	53	35
13.1 mg. green jack pine lignin	2	98	82	38
13.1 mg. green jack pine lignin	3	92	73	50
10.0 mg. green jack pine lignin	3	54	17	10
10.0 mg. green jack pine lignin	3	37	20	11
10.0 mg. green jack pine lignin and 10 mg. pitch as follows:				
Jack pine OP	3	79	20	17
Jack pine OP	3	71	30	20
Jack pine OP	2	72	31	17
Jack pine DP	3	75	31	20
Jack pine DP	3	72	32	17
Spruce OP (2 dispersions)	6	50	20	13
Spruce FP (2 dispersions)	5	29	0	0
Spruce DP (2 dispersions)	5	74	24	13

Note: OP = original pitch isolated from the original hot-water extract; FP = the pitch isolated from the foam; DP = the pitch isolated from the defoamed liquid. Foam data are averaged for the several measurements.

The original concentration values of 10 to 15 mg. lignin per 400 ml. were calculated from the actual amount of lignin isolated in the foam. Since it was felt that these might not be correct values, a reconstitution of the white water system was attempted. A green jack pine hot-water extract was concentrated *in vacuo* to a small volume and the galactan precipitated by the

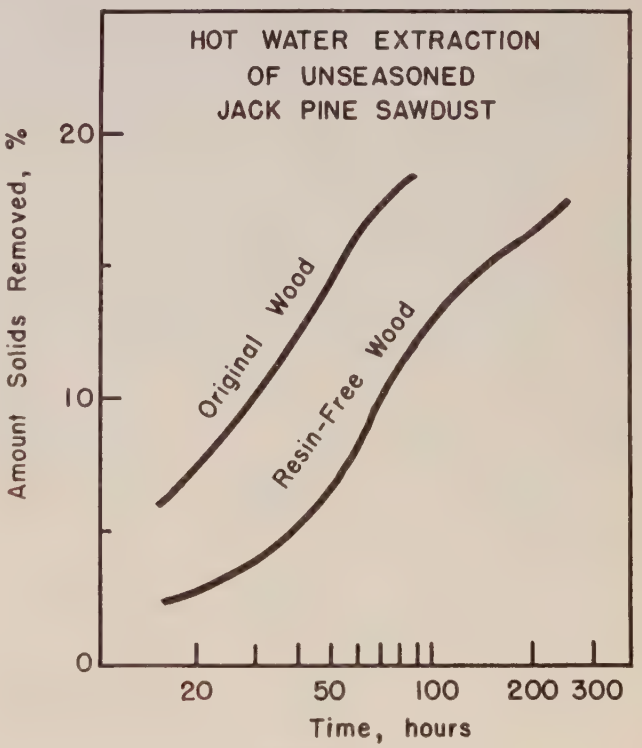

Fig. 16. Hot-water extraction of unseasoned jack pine sawdust

addition of ethanol. The ethanol-soluble fraction, which contained both lignin and pitch, was then dispersed in water as above. The resulting dispersion foamed very weakly, a disappointing result. This either means that certain components in the green jack pine extract depress the foam or that the synthetic dispersions differ in their nature from the hot-water extracts.

The foaming ability of jack pine and of spruce lignin in aqueous dispersion seems to be of the same order of magnitude. The spruce lignin values, although lower than those for jack pine, are much higher than those expected for data for hot-water extracts prepared from sawdust. The addition of jack pine pitch to the jack pine lignin dispersions increased the stability greatly but not to the desired point. Pitch dispersed alone in water showed no foaming effect at all.

Attempts to show logical stabilizing or depressing effects for the various pitches were disappointing and can probably be attributed to the transient colloidal nature of these materials. A stabilizing effect was shown by jack pine pitch, whether isolated from the foam, the defoamed liquid, or the original hot-water extract. In the case of spruce pitch, a stabilizing effect was shown by the pitch from the defoamed liquid and a

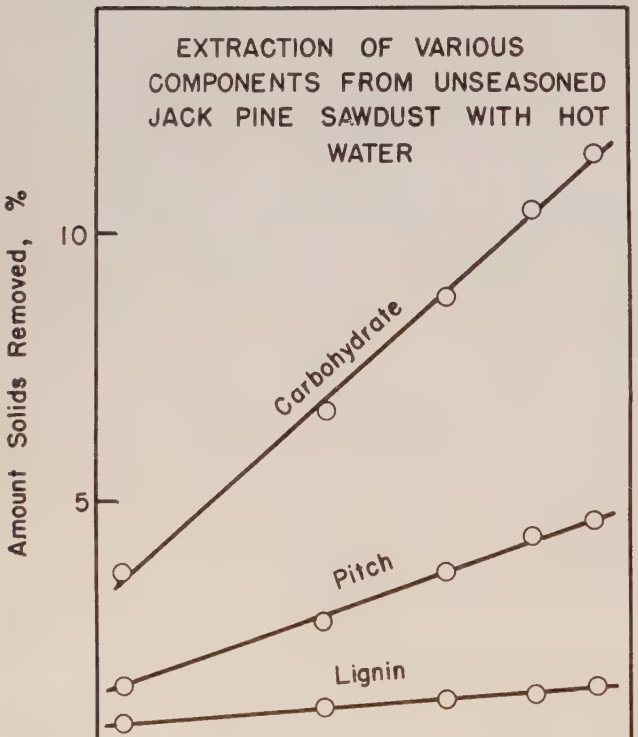

Fig. 17. Extraction of various components from unseasoned jack pine sawdust with hot water

depressing effect by the foam pitch, whereas the reverse effect was expected. The data given in Table XI, where pitch dispersions were made, are very uncertain and difficult to reproduce.

The strong foaming action of the residual lignin in the defoamed spruce or jack pine hot-water extracts represents another anomaly. A few limited experiments in foam fractionation of aqueous dispersions of

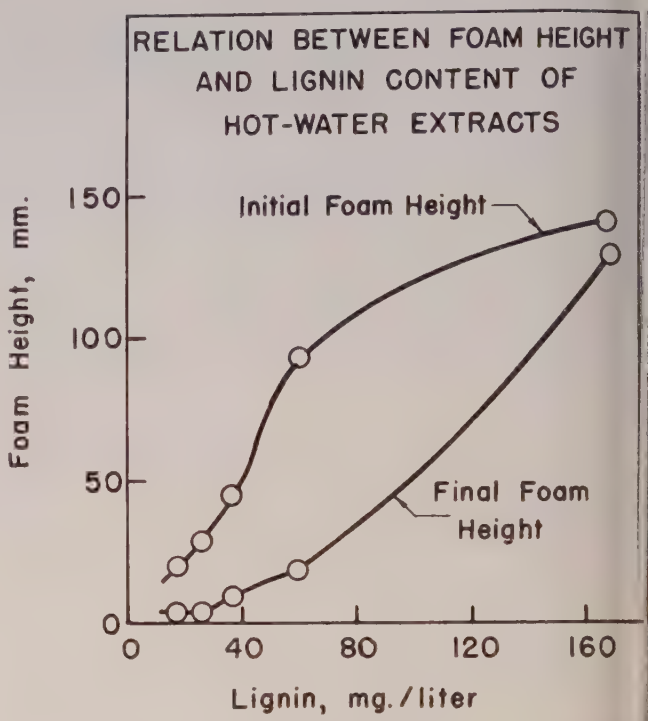

Fig. 18. Relation between foam height and lignin content of hot-water extract

native spruce lignin (kindly supplied by Dr. Brauns) gave only fractions of similar foaming ability; no weakly foaming lignin could be isolated.

It had been hoped that the preparation of synthetic dispersions would lead to a clean-cut explanation of the foam behavior of the hot-water extracts of green and seasoned jack pine and of spruce sawdust. However, with the present techniques in preparing colloidal dispersions and the unstable character of pitch, no definite conclusions can be drawn at this stage.

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ASSOCIATION NEWS AND EVENTS

Fall Meetings

The TAPPI Testing Conference was held at Syracuse on Sept. 10–12, 1952. The Seventh Engineering Conference of the Pulp and Paper Industry will be in session when this publication goes to press (Oct. 13–16, 1952).

On Oct. 27–28, 1952, the Ninth Fibrous Agricultural Residues Conference will be held at the Northern Regional Research Laboratory at Peoria, Ill.

The Plastics Conference will be held at the College of Forestry, State University of New York, Syracuse, N. Y., on Nov. 5–6, 1952.

The Sixth Alkaline Pulping Conference will be held at the Battle House, Mobile Ala., on Nov. 12–14, 1952. Plant visits will be made to the mills of Hollingsworth & Whitney Co. and the Southern Kraft Corp., International Paper Co.

On Nov. 20–21, 1952, the Corrugated Containers Conference will be held at the Hotel Schroeder, Milwaukee, Wis.

The Annual Meeting of TAPPI will be held at the Commodore Hotel, New York, N. Y., on Feb. 16–19, 1953. Individuals desiring to present papers at this meeting should advise the Secretary of TAPPI, 122 E. 42nd St., New York 17, N. Y.

Pulp and Paper Manufacture

Two thousand six hundred and sixty-eight copies of Volumes 1 and 2 of the textbooks on Pulp and Paper Manufacture were sold in the first six months of this year, in the ratio of five to eight and at the rate of seventeen volumes a day.

Bibliography of Papermaking 1950–1951

The annual Bibliography of Papermaking 1950–1951 has been distributed to the members of the Technical Association. Again the Association and the Industry are indebted to Clarence J. West of The Institute of Paper Chemistry and Chairman of the TAPPI Bibliography Committee for the preparation of this important publication.

Last year the collective Bibliography covering 1946–1950 omitted the patents issued in 1950. These have been included in the 1950–1951 Bibliography, together with those issued in 1951.

Protein and Synthetic Adhesives

TAPPI Monograph No. 9, "Protein and Synthetic Adhesives for Paper Coatings," has been distributed to members of the Technical Association of the Pulp and Paper Industry.

The monograph was sponsored by the Coating Committee, John H. Heuer, Great Northern Paper Co., Chairman. The preparation of the TAPPI coating monographs was initiated by the committee under the chairmanship of Werner Kaufmann, retired.

The authors of No. 9 are: W. M. Bain, R. S. Burnett, Miss R. M. Karapetoff Cobb, W. R. Eichenberger, G. K. Greminger, J. R. Hubbard, W. B. Morehouse, T. S. Morse, F. P. Nabenhouer, A. W. Neubauer, R. A. Olson, S. R. Sheeran, L. H. Silvernail, E. K. Stilbert, R. Tutt, Jr., and R. M. Upright. The Association is particularly indebted to Miss R. M. K. Cobb, Consultant to the Lowe Paper Co., Ridgefield, N. J., for her leadership and effort in preparing this very useful and authoritative monograph.

The subjects covered are: Manufacture of Casein, Casein in Paper Coating, Animal Glue in Coated Paper, Manufacture and Chemistry of Isolated Soybean Protein, Soya Protein Adhesives for Coated Papers, Methylcellulose, Latexes for Paper Coating, Polyvinyl Alcohol and Polyvinyl Acetate in the Paper Industry, Sodium Carboxymethylcellulose, and Foam Control in Paper Coating.

Sixth Alkaline Pulping Conference

The Sixth Alkaline Pulping Conference will be held at the Battle House, Mobile, Ala., on Nov. 12–14, 1952. Following is the tentative program:

Wednesday, November 12

9:30 a.m. Sulphur and Soda Recovery Session

Robert B. Reynolds, Hollingsworth & Whitney Co., Mobile, Ala., Chairman

1. "Use of Sulphur in Kraft Pulp Mills," J. E. Vassie, International Paper Co., Camden, Arkansas
2. "Heat Transfer Study of Sulphate Black Liquor," by R. L. Harvin, University of Florida, Gainesville, Fla.
3. "Submerged Combustion Evaporation," by William I. Weisman, Ozark-Mahoning Co., Tulsa, Okla.
4. "The Effect of Sulphidity on Bleached Sulphate Pulp Strength," by M. B. Pineo, Brunswick Pulp and Paper Co., Brunswick, Ga.
5. "Use of Flue Gases for Black Liquor Evaporation." Panel discussion. Panel: C. L. Durkee, D. J. Murray Mfg. Co., Wausau, Wis.; W. J. Darmstadt, Babcock & Wilcox Co., New York, N. Y.; Frank W. Hochmuth, Combustion Engineering-Superheater, Inc., New York, N. Y.; and G. H. Tomlinson, Howard Smith Paper Mills Ltd., Cornwall, Ont.

2:00 p.m. Recovery Room Operation Session

John J. Goss, Gaylord Container Corp., Bogalusa, La., Chairman

1. "New Developments in Recovery Furance Design," by Frank W. Hochmuth, Combustion Engineering-Superheater, Inc., New York, N. Y.
2. "New Developments in Recovery Furnace Design," by W. J. Darmstadt, Babcock & Wilcox Co., New York, N. Y.
3. "Instrumentation of Recovery Furnaces," by J. R. Upson and T. C. Johnson, Union Bag & Paper Corp., Savannah, Ga.
4. "Recovery Operation Corrosion Problems," by H. O. Teeple, International Nickel Co., New York, N. Y.
5. "The Liquor Cycle Operation from an Operator's Viewpoint," by J. L. Brown, Brunswick Pulp & Paper Co., Brunswick, Ga.
6. "Recovery Furnace Operation." Panel discussion. Panel: G. L. Tomlinson, Howard Smith Paper Mills, Ltd., Cornwall, Ont.; Wilbur L. Orr, St. Regis Paper Co., Pensacola, Fla.; and George H. Whiteside, Container Corp. of America, Fernandina, Fla.

6:00 p.m. Social Hour and Smorgasbord, Battle House, Mobile Ala.

Thursday, November 13

9:00 a.m. Reduction of Kraft Mill Odors Session

Robert R. Fuller, Gulf States Paper Corp., Tuscaloosa, Ala.

1. "Masking the Sulphate Mill Odor," by B. K. Tremaine, Industrial and Aromatics Section, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
2. "Experience in the Abatement of Kraft Mill Odors," by Ben F. May, Gulf States Paper Co., Tuscaloosa, Ala.
3. "Odor Compounds of the Kraft Process," by Walter Menly, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

4. "Design of Chimneys for Odor Dispersion," by F. L. Cate, Rust Engineering Co., Pittsburgh, Pa.
5. "Elimination of Odors with Chlorine Compounds," by E. R. Woodward, Mathieson Chemical Co., Baltimore, Md.
6. "Odor Counteraction," by Representative of Airkem, Inc., New York, N. Y.

12:00 m. LUNCHEON

Speaker—Judge Ben. D. Turner

2:00 p.m. GENERAL SESSION

Fred W. Bishop, Southland Paper Mills, Inc., Lufkin, Texas

1. "Turbulent Suspension Burning of Wood Refuse and Other Fuels." A film and discussion by Otto de Lorenzi, Combustion Engineering-Superheater, Inc., New York, N. Y.
2. "Deterioration Losses in Stored Southern Pine Pulpwood," by Ralph M. Lindgren, Principal Pathologist, Forest Products Laboratory, Madison, Wis.
3. "Evaluation of Bleached Kraft Pulp for Paperboard Manufacture," by R. L. Lewis, Ohio Boxboard Co., Rittman, Ohio.
4. "Kraft Mill Effluents," by Anthony W. Pesch, Southern Kraft Division, International Paper Co., Mobile, Ala.

Friday, November 14

9:30 a.m. Visit to mill of the Southern Kraft Division, International Paper Co., Mobile, Ala.
2:00 p.m. Visit to Mill of the Hollingsworth & Whitney Co. Chickasaw, Ala.

Ladies Program

Wednesday, November 12

2:00 p.m. Trip to World Famous Bellingrath Gardens
6:00 p.m. Social Hour and Smorgasbord, Battle House, Mobile, Ala.

Thursday, November 13

2:00 p.m. Boat Ride Down Mobile Bay

Friday, November 14

12:30 p.m. Luncheon at the Grand Hotel

Hotel Reservations

Hotel room reservations should be made early at the Battle House, Admiral Semmes Hotel, and Cawthon Hotel, all in Mobile. A large attendance is expected.

Mobile is an interesting city. The Conference program is so arranged that all in attendance will have an ample opportunity to see the historical places and fully enjoy the Deep South.

Plastics Conference

The TAPPI Plastics Conference will be held at the College of Forestry, State University of New York, Syracuse, N. Y., on Nov. 5–6, 1952.

In addition to the program published in earlier issues of *Tappi*, R. F. Vokes of the Dilts Machine Works, Fulton, N. Y., will present a paper on "Methods of Reverse Roll Coating."

On the afternoon of November 6 there will be a visit to the new coating laboratory of the Dilts Machine Works.

Corrugated Containers Conference

The TAPPI Corrugated Containers Conference will be held at the Schroeder Hotel, Milwaukee, Wis., on Nov. 20–21, 1952. The Chicago Section of the Technical Association will be a joint sponsor of the conference with the Corrugated Container Committee.

The program of November 20 will be devoted to papers and panel discussions. November 21 will be devoted to plant tours through the corrugating departments of the Cornell Paperboard Products Co., Downing Box Co., and the Gaylord Container Corp.

Highlighting the first-day conference will be a résumé of the industry survey on "Combining," made by the Corrugated Containers Committee. Presenting the analysis of this, the most complete survey made to date on corrugated combining, will be H. T. Scordas, of the Union Bag & Paper Corp., Savannah, Ga.

W. R. Tobin of the American Boxboard Co., Grand Rapids, Mich., will be the Session Moderator. Papers to be presented at the panel session are:

"Problem Analysis," by Vance V. Vallandigham, Potlatch Forest Industries, Lewiston, Idaho. (In this presentation Mr. Vallandigham will bring together operating problems from all over the country)
"Warping and Washboarding," by C. R. Vander Meulen, Penick & Ford, Inc., Ltd., Cedar Rapids, Iowa
"High-Low Corrugations," by F. E. Skiver, American Boxboard Co., Grand Rapids, Mich.
"Corrugator Delivery Tables," by A. F. Sperling, Downing Box Co., Milwaukee, Wis.
"An Operator Designs a Corrugator," by K. W. Max, Robert Gair Co., Inc., Uncasville, Conn.

The plant tours on November 21 will be organized so that everyone will visit the corrugating departments of all three plants.

All inquiries about the program may be directed to Burt Mendlin, Secretary of the TAPPI Corrugated Containers Committee, Cornell Paperboard Products Co., 1514 E. Thomas Ave., Milwaukee, Wis.

Statistics Conference

About thirty-six research workers and quality control men in the paper industry attended a two-week conference on the Application of Statistics at the University of Maine, Orono, Me., from Aug. 4–16, 1952.

The conference was sponsored by the Technical Association of the Pulp and Paper Industry and the University.

The purpose of the conference was to give preliminary training in the use of statistical methods in research, production, and quality control.

The instructors were: Professor Geoffrey Beall of the University of Connecticut, Storrs, Conn., Charles W. Bicking, Research and Ordnance Division, United States Army, Washington, D. C., Barry G. Wingersky, Chief Statistician, Department of Market Research, Gillette Safety Razor Co., Boston, Mass., and Prof. Spoffard H. Kimball, Head of the Mathematics Department, University of Maine. In addition there were several special lecturers for the evening sessions.

Following is the schedule of lectures and talks given at the conference:

Monday, August 4

Lec. 1. Introduction. 9:00–9:55 a.m. Prof. Kimball.
Lec. 2. "The Chance Variation and Variability of (Measured) Strength Tests." 10:00–10:50 a.m. Prof. Beall.
Lec. 3. "Control Charts for Strength Tests (Individual Items and Means)." 11:00–12:00 a.m. Dr. Bicking.
Talk I. "Some Influences of Paper Machine Design and Operation on the Variability of Paper Board." 7:00–9:00 p.m. Dr. Bicking.

Tuesday, August 5

Lec. 4. "Control Charts for Range of Tests." 9:00–9:45 a.m. Dr. Bicking.
Lab. I. "The Application of Control Charts for x-Bar and R." 10:00–11:50 a.m.
Lec. 5. "The Confidence Limits of a Mean of a Strength Test." 12:00 noon–1:00 p.m. Dr. Wingersky.
Talk II. "Process Control." 7:00–9:00 p.m. Maurice Blew, Strathmore Paper Co.

Wednesday, August 6

Lab. II. "The Calculation of Confidence Limits for Strength Test." 9:00–10:25 a.m.
Lec. 6. "The Chance Variation of Defects." 10:30–11:20 a.m. Prof. Kimball.
Lab. III. "The Calculation of Binomial Distributions." 11:30 a.m.–1:00 p.m.
Talk III. "The Design and Analysis of Experiments on Paper Quality." 7:00–9:00 p.m. L. K. Reitz, Eastman-Kodak Co.

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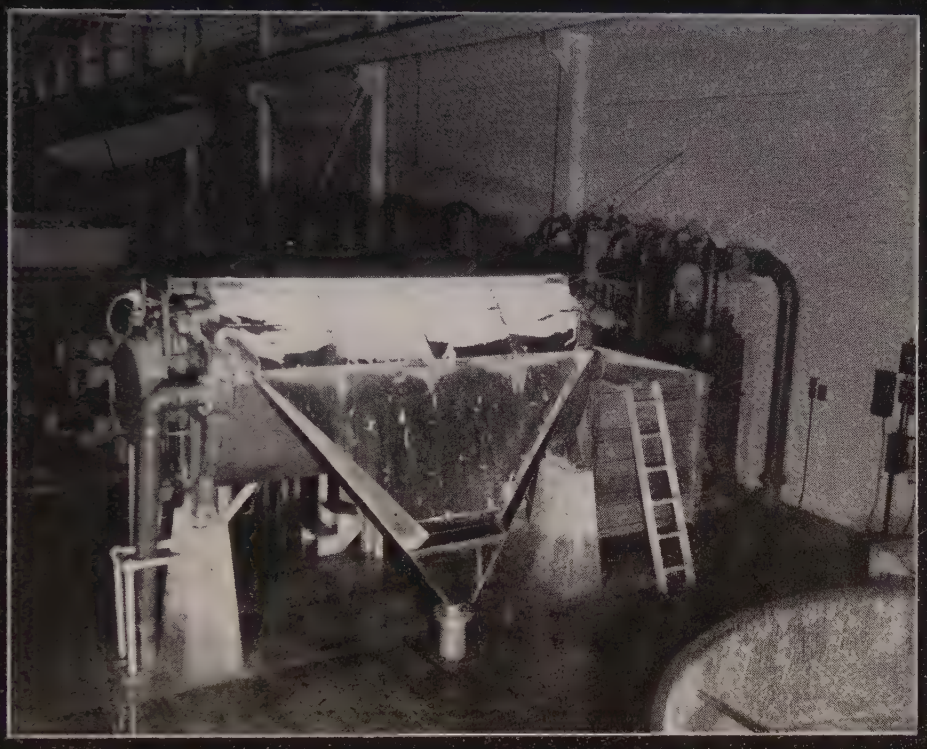

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Thursday, August 7

Lec. 7. "Control Charts for Fraction Defective." 9:00–9:55 a.m. Prof. Beall.

Lec. 8. "Tests of the Significance of a Difference." 10:00–10:55 a.m. Dr. Wingersky.

Lab. IV. "The Application of Control Charts for Defects and Applications of Double Sampling." 11:00 a.m.–1:00 p.m.

Friday, August 8

Lec. 9. "The Confidence Limits of Fraction Defective." 9:00–9:55 a.m. Dr. Wingersky.

Lab. V. "The Calculation of Confidence Limits for Fraction Defective." 10:00–11:50 a.m.

Test of Constituents (Regression)." 10:00–10:50 a.m. Prof. Beall.

Lab. VIII. "The Calculation of Regression." 11:00 a.m.–1:00 p.m.

Talk VII. "Application of Correlation Analysis." 7:00–9:00 p.m. T. H. Geiger and P. M. Schaffrath, Oxford Paper Co.

Thursday, August 14

Lec. 17. "Variability of a Regression." 9:00–9:55 a.m. Dr. Bicking.

Lab. IX. "The Calculation of Confidence Limits of a Regression." 10:00–11:55 a.m.

Lec. 18. "The Correlation, of Strength Characters." 12:00 noon–1:00 p.m. Dr. Wingersky.

Statistics Conference: Front row, left to right: H. Chester McLaughlin, Kedwick R. Martin, John F. Langmaid, Jr., Arthur P. Feather, Ray E. Smith, Jr., Thomas W. Bauer, Spofford H. Kimball, Geoffrey Beall, Theodore H. Geiger, Charles M. Koon, Allan E. Paull, O. John Lombard, Ronald G. MacDonald; Second row: Alvin R. Shade, Louis A. Klein, Peter P. Taranoff, Peter E. Verdicchio, Joseph F. Theriault, Robert J. Harlow, Frederick J. McLeod, George R. Shaw, Charles E. Bicking, David W. Reid, Bary G. Wingersky; Third row: Gloria Bernier, William H. Crosier, Jr., William A. Welsh, Jr., Robert E. Spruiell, Russell L. Lewis, William D. Rice, W. Peyton Blamire, Edward W. Beauvais; Fourth row: Benjamin Thomas, Stanley J. Pasternak, Paul M. Schaffrath, Lyle C. Jenness

Lec. 10. "How to Go About an Investigation in a Mill." 12:00 noon–1:00 p.m. Dr. Bicking.

Talk V. "Application of Control Charts in the Plastics Division." 7:00–9:00 p.m. J. D. Hinchen, Monsanto Chemical Co.

Monday, August 11

Lec. 11. Introduction. 9:00–9:25 a.m. Prof. Kimball.

Lec. 12. "The Analysis of Variance." 9:30–10:50 a.m. Prof. Beall.

Lab. VI. "The Test of Significance in Analysis of Variance." 11:00 a.m.–1:00 p.m.

Talk V. "Statistical Techniques in Research and Development Work Connected with Pulp Bleaching." 7:00–9:00 p.m. F. R. Sheldon, Buffalo Electro-Chemical Co.

Tuesday, August 12

Lec. 13. "Application of Control Charts When There Is More Than One Kind of Variability." 9:00–9:55 a.m. Dr. Bicking.

Lab. VII. "The Analysis of Variability in and Across a Machine." 10:00–11:50 a.m.

Lec. 14. "The Partition of Variance." 12:00 noon–1:00 p.m. Prof. Beall.

Talk VI. "Some Basic Concepts of Quality Control." 7:00–9:00 p.m. W. R. Purcell, Brown Co.

Wednesday, August 13

Lec. 15. "Two-Way Analysis of Variance as an Experimental Tool." 9:00–9:55 a.m. Dr. Bicking.

Lec. 16. "The Anticipation of Corrugated Board Strength

Talk VIII. "Application of Control Charts and Distribution Diagrams." 7:00–9:00 p.m. G. R. Shaw, Taylor Fibre Co.

Friday, August 15

Lec. 19. "The Correlation of Strengh Characters (*continued*). 9:00–9:55 a.m. Dr. Wingersky.

Lec. 20. "The Chance Variability of a Correlation." 10:00–10:50 a.m. Prof. Beall.

Lab. X. "The Calculation of Correlations." 11:00 a.m.–1:00 p.m.

Those attending the conference were: T. W. Bauer, Abitibi Power & Paper Co., Sault Ste. Marie, Ontario; E. W. Beauvais, American Box Board Co., Filer City, Mich.; Gloria Bernier, St. Regis Paper Co., Deferiet, N. Y.; W. P. Blamire, American Box Board Co., Grand Rapids, Mich.; A. E. Conklin, C. A. Reed Co., Williamsport, Pa.; W. H. Crosier, Byron Weston Co., Dalton, Mass.; C. C. Darcey, Gulf States Paper Corp., Tuscaloosa, Ala.; A. P. Feather, West Virginia Pulp & Paper Co., Mechanicville, N. Y.; T. H. Geiger, Oxford Paper Co., Rumford, Me.; R. J. Harlow, Robert Gair Co., Uncasville, Conn.; L. A. Klein, Gulf States Paper Corp., Tuscaloosa, Ala.; C. M. Koon, Oxford Paper Co., Rumford, Me.; G. R. Kuhlman, Personal Products Corp., Milltown, N. J.; J. F. Langmaid, S. D. Warren Co., Cumberland Mills, Me.; R. L. Lewis, Ohio Box Board Co., Rittman, Ohio; O. J. Lombard, Great Northern Paper Co., Millinocket, Me.; J. D. Lyall, Armstrong Cork Co., Lancaster, Pa.; K. Martin, Fort Wayne Corrugated Paper Co., Hartford City, Ind.; H. C. McLaughlin, New York and Pennsylvania Co., Lock Haven, Pa.; F. J. McLeod, C. H. Dexter & Sons, Windsor Locks, Conn.; A. H. Nadelman, Western Michigan College of Education, Kalamazoo, Mich.; S. J. Pasternak, Hollingsworth &

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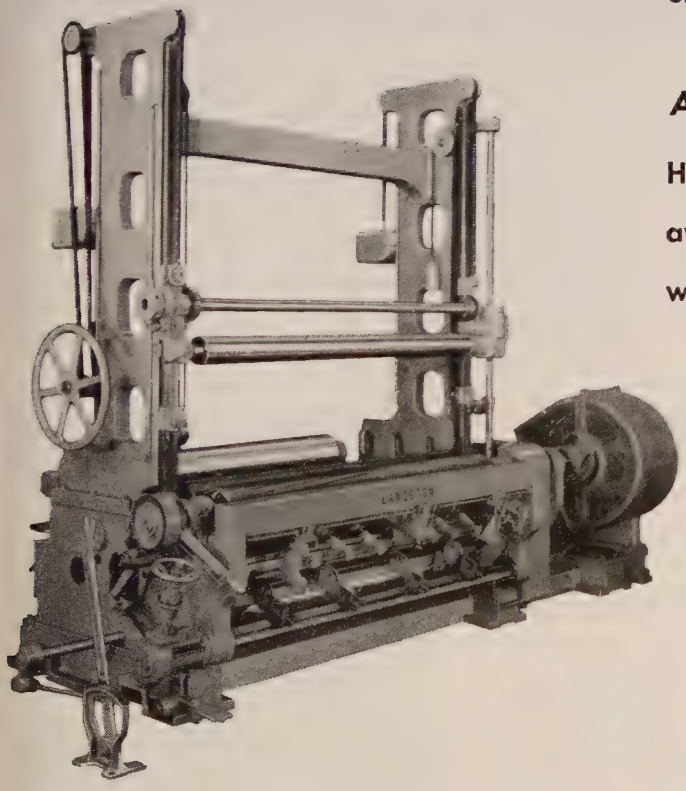

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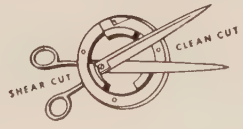

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Vose Co., West Groton, Mass.; A. E. Paull, Abitibi Power & Paper Co., Toronto, Ontario; D. W. Reid, Union Bag & Paper Co., Savannah, Ga.; W. D. Rice, P. H. Glatfelter Co., Spring Grove, Pa.; P. N. Schaffrath, Oxford Paper Co., Rumford, Me.; A. R. Shade, Fibreboard Products, San Francisco, Calif.; G. R. Shaw, Taylor Fibre Co., Norristown, Pa.; R. E. Smith, Oswego Falls Corp., Fulton, N. Y.; R. E. Spruiell, Gulf States Paper Corp., Tuscaloosa, Ala.; P. P. Taranoff, St. Helens Pulp & Paper Co., St. Helens, Ore.; J. Therriault, Robert Gair Co., Uncasville, Conn.; B. Thomas, Lowe Paper Co., Ridgefield, N. J.; P. E. Verdicchio, West Virginia Pulp & Paper Co., Mechanicville, N. Y.; W. A. Welsh, Container Corp. of America, Wilmington, Del.

Third Testing Conference

The first of the Fall Conferences sponsored by the Technical Association was held by the TAPPI Testing Division at the State University of New York, College of Forestry in Syracuse, N. Y. The meetings, which were attended by 138 individuals, were held Sept. 10–12, 1952.

The group which attended the Third Testing Conference at the College of Forestry, State University of New York, Syracuse, N. Y., Sept. 10–12, 1952

In contrast to the other conferences, there was no set program, each committee of the Testing Division holding informal meetings to discuss various testing methods considered for the TAPPI Standards. It is expected that each of the committees will issue a report which will be published in a later issue of *Tappi*.

The following committees held meetings: Nonfibrous Materials Testing Committee, J. P. Casey, A. E. Staley Mfg. Co., Chairman; Wax Testing Committee, A. M. Heald, Scott Paper Co., Chairman; Pulp Testing Committee, R. I. Thieme, Soundview Div., Scott Paper Co., Chairman; Microscopy Committee, C. E. Brandon, Howard Paper Mills, Chairman; Paper Testing Committee, D. H. Newcomb, Riegel Paper Corp., Chairman; Packaging Materials Testing Committee, L. E. Simerl, Marathon Corp., Chairman; and the Chemical Methods Committee, A. S. O'Brien, Eastman Kodak Co., Chairman.

On Thursday noon the group had its luncheon at Drumlins. James d'A. Clark, Chairman of the Testing Division, acted as toastmaster. During the luncheon it was proposed that a telegram should be sent to Roger C. Griffin, the Chairman of the Standards Committee who has served so many years in this exacting position and has been of so much service to the Division as well as to the Technical Association as a whole. Acting on this proposal, Mr. Clark sent the following telegram:

"Today at the luncheon of the Testing Division of TAPPI it was resolved with enthusiastic acclamation, to send you, on behalf of each chairman and their committees present, our many thanks for your helpfulness and guidance over the past years, our warmest greetings, and our best wishes for the future."

The large number of interested members who attended was appreciated by the various chairmen, and through their efforts it is expected that the TAPPI Standards will be improved to the benefit of all the industry. Meetings such as this and the previous ones held at the Mellon Institute in Pittsburgh, Pa., and at the Eastman Kodak Co. at Rochester, N. Y., have done much to create a better understanding of the problems by the members of committees and all those interested in their work.

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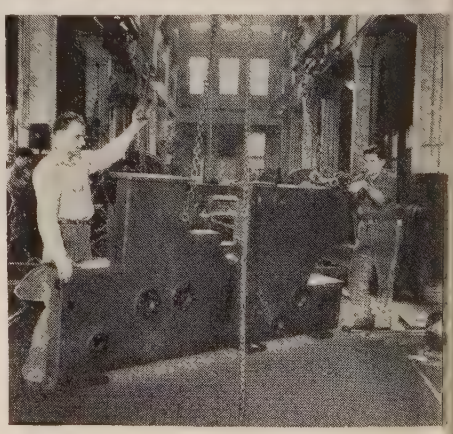

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PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Herman R. Amberg, Resident Engineer, West Coast, National Council for Stream Improvement of Pulp, Paper & Paperboard, Inc., Portland, Ore., a 1943 graduate of Syracuse University.

Louis-Philippe Amiot, Professor of Chemistry, Faculty of Forestry, Laval University, Que., P. Q., Canada, a 1937 graduate of Laval University with a Ph.D. degree in 1944.

Robert M. Babb, Mechanical Engineer, Merritt-Chapman & Scott Corp., New York, N. Y., a 1939 graduate of the University of Tennessee.

Tillman H. Bach, Quality Control, Julian B. Slevin Co., Inc., East Lansdowne, Pa.

Guenther Baeumlein, Director of Research, Papierfabrik Schoeller & Hoesch G.m.b.H., Germsbach/Baden, Germany, a 1921 graduate of Freiburg College with a Ph.D. degree.

Albert F. Blockman, Physicist, American Cyanamid Co., Stamford, Conn., a 1931 graduate of New York University.

Oscar D. Bluthardt, Vice-President, R.B.H. Dispersions Div., Interchemical Corp., Bound Brook, N. J., a 1922 graduate of the University of Illinois.

Jacob K. Cushman, Mechanical Engineer, Alton Box Board Co., Alton, Ill. Attended Rose Polytechnic Institute.

Howard A. Davis, Senior Engineer, Sprague Electric Co., North Adams, Mass., a 1940 graduate of Ohio State University.

W. Fred Denning, Salesman, Swift & Co., Soap Dept., Chicago, Ill.

Raymond K. Erhardt, Superintendent, Folding Carton Production, Wilson Paper Box Co., Richmond, Va., a 1935 graduate of the University of Illinois.

Mineo Fujimoto, General Manager, Goozu Mill, Sanyo Pulp Co., Goozu-Machi, Shimane-Ken, Japan, a 1924 graduate of Kyoto Imperial University.

Daniel C. Gillespie, Chemical Engineer, The Dorr Co., Stamford, Conn., a 1943 graduate of Pennsylvania State College.

Donald E. Grossnickle, Project Engineer, The Meade Corp., Chillicothe, Ohio, a 1947 graduate of Purdue University.

Richard L. Harvin, Assistant Professor of Chemical Engineering, University of Florida, Gainesville, Fla., a 1944 graduate of the University of Louisville.

Robert J. Herschler, Research Chemist, Crown Zellerbach Corp., Camas, Wash., a 1948 graduate of Washington University, St. Louis, Mo.

Lewis K. Hosfeld, Chemist, Keasbey & Mattison Co., Ambler, Pa., a 1951 graduate of Lehigh University.

William A. Hosmer, Chemist, General Electric Co., Pittsfield, Mass., a 1948 graduate of the University of Massachusetts.

Harry D. Kiplinger, Chemist, Fibreboard Products, Inc., Antioch, Calif., a 1950 graduate of the University of California.

Michael S. Koch, Technical Librarian, Naval Supply Activities, New York, Brooklyn, N. Y., a 1930 graduate of Washington University, St. Louis, Mo.

Robert S. Kraiman, Quality Control Assistant, W. C. Hamilton & Co., Miquon, Pa., a 1952 graduate of the New York State College of Forestry.

Helen E. Loftus, Assistant Librarian, The Lilly Research Laboratories, Indianapolis, Ind.

William M. Lyerly, Process Engineer, General Electric Co., Coshocton, Ohio, a 1949 graduate of Purdue University.

Arthur E. May, Assistant Chief Engineer, The Moore & White Co., Philadelphia, Pa., a 1933 graduate of the University of Wisconsin.

Benjamin F. May, Chief Chemist, Gulf States Paper Corp., Tuscaloosa, Ala., a 1951 graduate of the University of Alabama.

Earl S. McColley, Chief Chemist, Celanese Corp. of America, Rock Hill, S. C., a 1941 graduate of Boston University.

Howard M. Merkle, Chemist, Empire Box Corp., Stroudsburg, Pa., a 1939 graduate of Western Michigan College.

James A. Mitchell, Technical Superintendent, E. I. du Pont de Nemours & Co., Inc., Richmond, Va., a 1930 graduate of Johns Hopkins College with a Ph.D. degree.

Mary A. Mitchell, Librarian, Dominion Tar & Chemical Co. Ltd., Montreal, P. Q., Canada, a 1951 graduate of Marianopolis College.

William W. Monks, Jr., Student, Northeastern University, Boston, Mass.

J. Ronald Murray, Sales Engineer, Babcock & Wilcox Co., Chicago, Ill., a 1938 graduate of Purdue University.

Henry G. Nelson, Supervisor, Shipping Container Research Laboratory, Owens-Illinois Glass Co., Toledo, Ohio, a 1931 graduate of the University of Minnesota.

Ralph M. Newman, Jr., Sales Engineer, The Pusey & Jones Corp., Wilmington, Del., a 1947 graduate of the University of Delaware.

Migita Nobuhiko, Professor, Pulp and Wood Chemistry, Agricultural Dept., Tokyo University, Tokyo, Japan, a 1932 graduate of Tokyo University with a Dr. of Agric. degree.

Othon Paez, Paper Mill Superintendent, Empaques de Carton Titan, S. A., Monterrey, N. L., Mexico. Attended the University of Dayton.

Luis L. Pardo, Division Chief, Forest Chemistry, Administracion Nacional de Bosques, Buenos Aires, Argentina, a 1944 graduate of the University of Buenos Aires, with a Dr. in Chemistry degree.

Philip A. Peterson, Sales Engineer, Rice Barton Corp., Worcester, Mass., a 1944 graduate of Yale University.

Harold A. Samuelson, Physicist, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., a 1929 graduate of the University of Iowa.

Shozo Satake, Head, Technical Dept., Yokohama Electric Wire & Cable Works, Yokohama, Japan, a 1932 graduate of Tokyo High Technical College with a Dr. of Engr. degree.

Robert L. Schuerman, Technical Coordinator, A. E. Staley Mfg. Co., Decatur, Ill., a 1941 graduate of Purdue University.

Roy C. Selby, Electrical Engineer, St. Regis Paper Co., Pensacola, Fla.

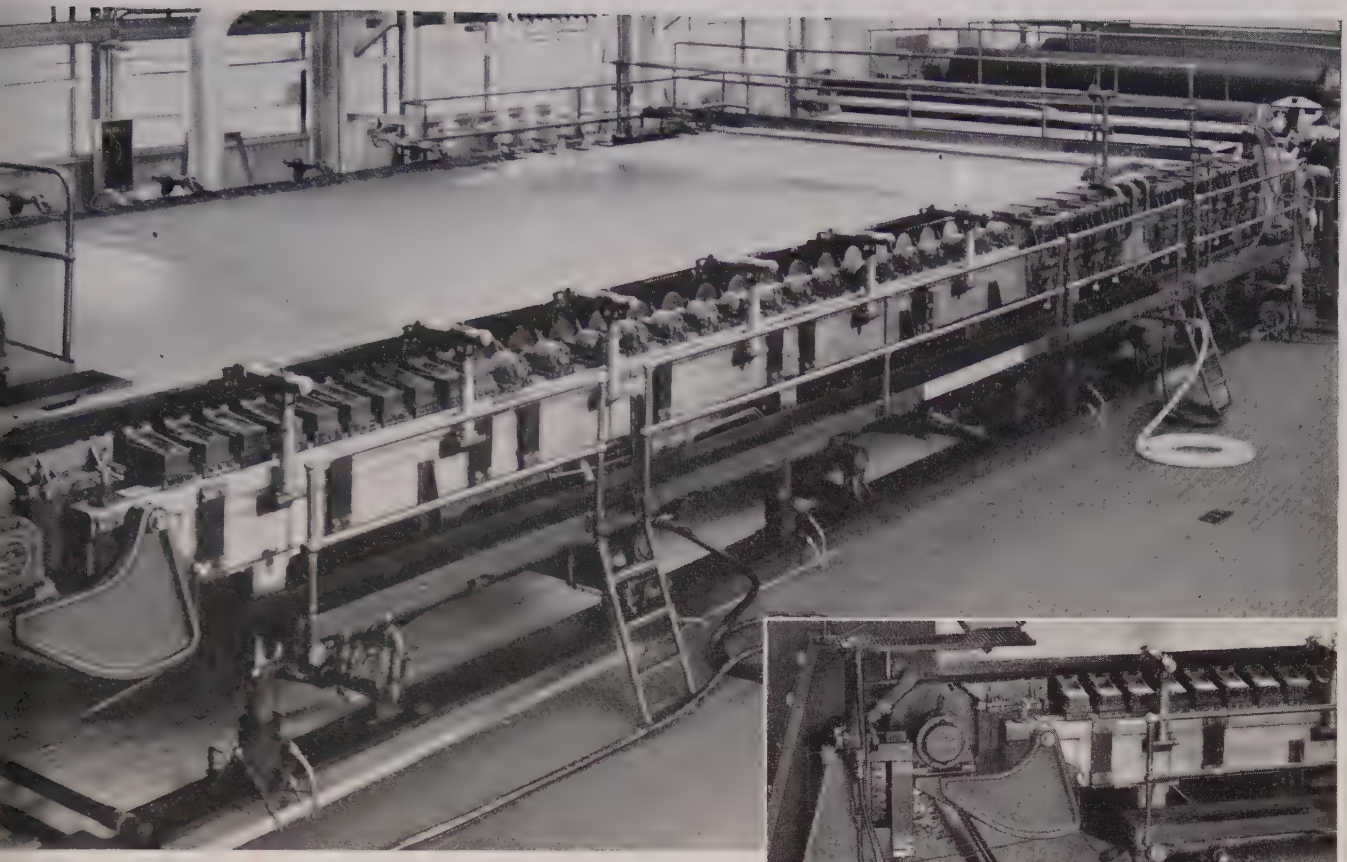
Harold B. Shepard, Forest Economist, Federal Reserve Bank of Boston, Boston, Mass., a 1914 graduate of Harvard Forest School.

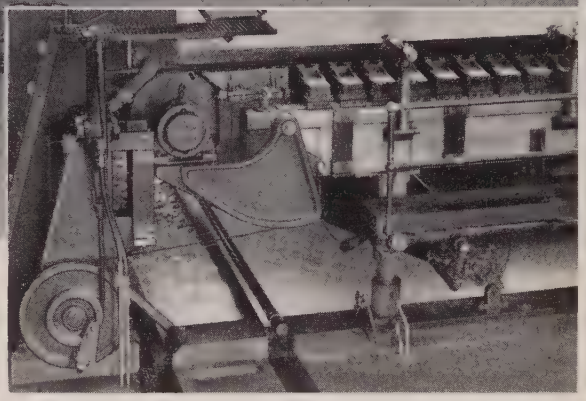
David E. Shotwell, Salesman, Interchemical Corp., Printing Ink Div., Cleveland, Ohio, a 1938 graduate of Michigan State College.

Gordon K. Singletary, Plant Manager, Brunswick Pulp & Paper Co., Brunswick, Ga.

Richard O. Spalding, Chief Packaging Engineer, Owens-Illinois Glass Co., Toledo, Ohio, a 1940 graduate of Massachusetts Institute of Technology.

Douglas Stephen, Chief Engineer, Sociedad Agricola Para-





During wire changing, the only parts of this Fourdrinier that actually move are Breast Roll which swings down, and inside Wire Return Rolls which swing up, hydraulically.

A MODERN FOURDRINIER...

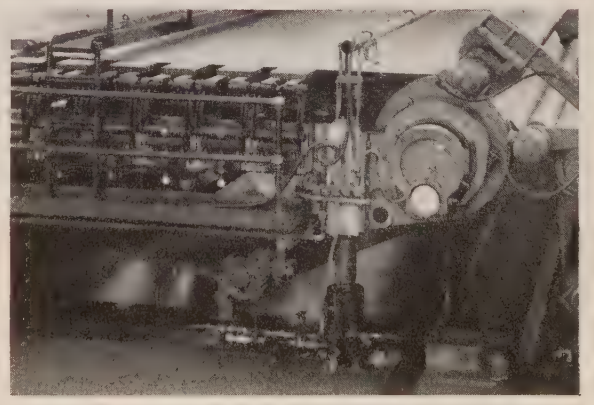
Completely New Design

Each new design and construction feature of this modern Fourdrinier is a contributing factor to the exceptionally fast wire changing for a minimum of non-productive down time. Lower operating costs, easier maintenance and higher production are the direct results.

This modern Fourdrinier, as illustrated here, is 120 feet long from Breast Roll to Suction Couch Roll and carries a 228 inch wire at a speed of 2200 feet per minute.

We invite your inquiries regarding the complete details and the application of the design to your needs or requirements in your modernization program.

The Suction Couch Roll has become an integral part of the Fourdrinier, another feature that eliminates removable pieces to handle or connections to break during wire changing.



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WATERTOWN NEW YORK

Finland Representative
Aktiebolaget Ekstroms Maskinaffar
Helsingfors, Finland

monga Ltd., Supe, Peru, a 1920 graduate of Robert Gordon's Technical College.

Albert R. Stronach, Laboratory Assistant, Waterfalls Tissue Corp., Mechanic Falls, Me.

Gilbert H. Swart, Director of Research, The General Tire & Rubber Co., Akron, Ohio, a 1927 graduate of the University of Washington.

Ichiro Tsuji, Chief, Stock Preparation Section, Jujo Paper Mfg. Co., Tokyo, Japan, a 1931 graduate of the University of Yokohama.

Robert S. Welch, Supervising Engineer, St. Regis Paper Co., Carthage, N. Y., a 1941 graduate of Clarkson College of Technology.

James F. Whalen, Jr., Salesman, Becco Sales Corp., Buffalo, N. Y., a 1941 graduate of the University of Alabama.

Robert W. Zion, Resident Mill Manager, Hudson Pulp & Paper Corp., New York, N. Y., a 1942 graduate of North Carolina State College.

TAPPI Notes

Ralph H. Ball, formerly of Columbian Cellulose Co. Ltd., is now Technical Director, Plastics Div., Celanese Corp. of America, New York, N. Y.

George E. Boger, formerly Chemist for W. C. Hamilton & Sons, is now with the Paper Products Mfg. Co., Swarthmore, Pa.

John W. Brooks, formerly Student at the N. Y. State College of Forestry, is now Paper Engineer for the Glassine Paper Co., West Conshohocken, Pa.

James S. Brown, Paper Mill Superintendent for the Marinette Paper Co., has been transferred from Glens Falls, N. Y., to Marinette, Wis.

Wentworth Brown is now Vice-President in Charge of Research Sales and Production of the Brown Co., Berlin, N. H.

John J. Carroll, formerly of Chemipulp Process, Inc., is now Sulphite Superintendent for the St. Regis Paper Co., Deferiet, N. Y.

C. L. Crain is now Production Manager of the Southern Kraft Div., International Paper Co., Mobile, Ala.

Robert E. Oates, Technical Sales Engineer for the Hercules Powder Co., has been transferred from Wilmington, Del., to San Francisco, Calif.

John B. Chandler, formerly of Buffalo Pumps, Inc., is now with Hank D. Jones, Manufacturers Agent of St. Petersburg, Fla., representing Cabble Wire Co. and Raybestos-Manhattan, Inc. He will be located at Jacksonville, Fla.

Alan A. Claflin, Manufacturer's Agent, has moved from 2 Storer St., to 113 State St., Boston 9, Mass.

N. L. Cochrane of the Container Corp. of America has been transferred from Circleville, Ohio, to Fernandina, Fla.

George P. Day, Research Director of the Brown Co., Berlin, N. H., received an honorary Doctor of Science degree in June from the University of New Hampshire.

Stanley P. Dittmar, Production Supervisor of Container Corp. of America, has been transferred from Chicago, Ill., to Seattle, Wash.

Mario Gislon is now Director of Production for Cartiere Burgo, Maslianico, Italy.

Richard P. Hamilton, formerly Student, N. Y. State College of Forestry, is now Research Chemist for St. Regis Paper Co., Deferiet, N. Y.

Fred P. Heil is now Assistant Designer for the Lockport Felt Co., Newfane, N. Y.

Royal S. Kellogg, Retired, has changed his address from Bradenton, to Palmetto, Fla.

Harry C. Kinne, Jr., formerly of the Manistique Pulp & Paper Co., is now Technical Service Engineer for the Oxford Paper Co., Rumford, Me.

John R. Knapp, formerly of the N. Y. State College of Forestry, is now Chemist for Texon, Inc., South Hadley Falls, Mass.

John Lewis, formerly of the University of Maine, is now Head of the Department of Paper Engineering, Lowell Textile Institute, Lowell, Mass.

Donald W. Libby, formerly Research Associate and Project Leader, N. Y. State College of Forestry, is now Chemical Engineer in the Research Dept. of Robert Gair Co., Inc., Uncasville, Conn.

William R. Lusignea of the Paper Manufacturers Co. has moved his office to 9800 Bustleton Ave., Philadelphia 15, Pa.

Donald R. MacKinnon, formerly Student at the University of Maine, is now in the Research Dept. of the Oxford Paper Co., Rumford, Me.

Robert F. McDonnell, formerly of the Erving Paper Mills, is now Plant Manager of the Standard Paper Mfg. Co., Richmond, Va.

Robert H. Mosher, formerly Plant Manager of the Miami Valley Coated Paper Co., is now in the Sales Div. of Munising Paper Co., Chicago, Ill.

Oertel O. Nadebaum is now Chief Works Chemist of the Australian Paper Mfgrs. Ltd., Melbourne, Victoria, Australia.

Roland A. Packard, formerly of the National Production Authority, is now Consultant in the Pulp and Paper Div. of the Mutual Security Agency, Washington, D. C.

John E. Parnell, formerly of the Crossett Lumber Co., is now Chemical Engineer in the Nylon Plant of E. I. du Pont de Nemours & Co., Chattanooga, Tenn.

Wesley L. Pearl, formerly of the Longview Fibre Co., is now Project Engineer for the General Electric Co., Richland, Wash.

Alex E. Reikes, Power Transmission Engineer for Graton & Knight, has been transferred from Worcester, Mass., to San Francisco, Calif.

Arthur L. Ross is now Assistant General Manager of the Southern Kraft Div., International Paper Co., Mobile, Ala.

Edward E. Stephenson, formerly Student at Western Michigan College, is now Chemical Engineer for the Sutherland Paper Co., Kalamazoo, Mich.

Edward J. Schroer, formerly of the Container Corp. of America, is now with the Inland Container Corp., Indianapolis, Ind.

James A. Wise is now Executive Vice-President and General Manager of the Kalamazoo Paper Co., Kalamazoo, Mich.

Robert A. Worden, formerly of the General Electric Co., is now engaged in quality control in the Tape Div. of the Minnesota Mining & Mfg. Co., St. Paul, Minn.

Donald A. Yateman, formerly Student at the N. Y. State College of Forestry, is now Paper Chemist for the Dixie Cup Co., Easton, Pa., and is on military leave.

* * *

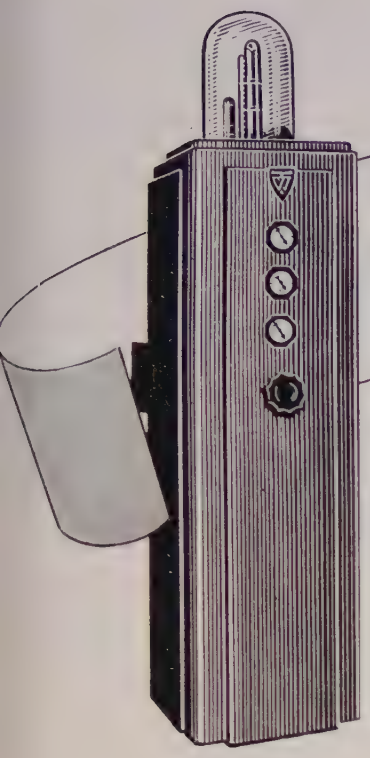
Edgar Andrews, Paper Industry Manager, has succeeded *H. A. Sholl* as the official representative of the Brown Instrument Co. Div., Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.

Industry Notes

Production and Consumption

Production of paper and board for the first seven months of the year was at a monthly average of 1,997,500 tons or an annual rate of 23,971,000 tons. The production of wood pulp for the first half of the year was 8,367,000 tons, the approximate level of production for the first half of last year. Consumption of wood pulp for the first half was 8,737,000 tons, 3% under the same 1951 period. Imports of wood pulp for 1952 through June amounted to 920,721 tons, a decline of 27% under imports for the same 1951 period.

Imports from Europe of 117,681 tons were a 62% decline, and imports from Canada of 803,040 tons were off 15%. Wood pulp exports for the January–June period were 133,000 tons, an increase of 24% over the same 1951 period.



This Machine Makes Paper

Better...

Faster...

Cheaper...

The machine is a W&T Visible Vacuum Chlorinator for the controlled and dependable application of chlorine to stock, white water and fresh water supply to destroy slime and odor producing micro-organisms.

It makes paper BETTER because by eliminating bacterial spots and off-odors it improves quality — obviously essential in food papers.

It makes paper FASTER because it reduces down-time due to sheet breakage, prevents the formation of slime in felts and improves water removal.

And, finally, it makes paper CHEAPER because it reduces stock, chemical and heat losses, improves grade and saves labor.

Write today to learn more about why leading paper and board mills everywhere have turned to W&T Chlorinators to solve bacteria-induced paper-making problems.

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COMPANY, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

1-39

Pulpwood receipts for the first half of the year amounted to 13,533,000 cords, a decline of 3% under receipts for the first half of 1951. Domestic receipts of 12,401,000 cords were down 3%, and imports 1,132,000 cords, were down 4%. Consumption of pulpwood for 1952 through June were 13,432,000 cords, a 2% increase over last year's comparable period. Inventories of 5,324,000 cords, though down about 1% under May were 27% above inventories at the end of June last year. Only the South showed a decrease, 8%.

Wastepaper

Preliminary figures of the Bureau of Census indicate that wastepaper consumption in the United States during the first half of this year aggregated 3,803,000 tons. This is substantially more than was consumed during the first six months of either 1949 or 1950. Compared with the last half of last year, wastepaper consumption during the first six months of this year dropped about 5%, but was 3% greater than the first half of 1950. Compared with the first six months of last year, consumption dropped about 23%. Here are the consumption figures for the last three and one-half years:

Year	*First half*	*Second half*	*Total*
1949	3,159,000	3,441,000	6,600,000
1950	3,692,000	4,264,000	7,956,000
1951	5,076,000	4,003,000	9,079,000
1952	3,803,000	.....	.....

During the first half of this year, the paperboard mills consumed 2,828,297 tons of wastepaper, the wet machine board mills 40,372 tons, the paper mills 595,347 tons, and the roofing and building material mills 338,511 tons.

Wastepaper has been consumed in increasing amounts, month by month, by the roofing and building material mills, and this increase is expected to continue. The monthly increase in wastepaper consumption by these mills from January to June was better than 20%.

Rhinelander

Installation of Wisconsin's first commercial scale evaporator for concentrating spent sulphite liquor is more than half completed at the Rhinelander Paper Co. mill. The estimated cost of $350,000 for this unit of equipment for reducing sulphite pollution in the Wisconsin River was ordered two years ago, but scarcities of the required stainless steel prevented the manufacturers from fabricating it until this Summer. Now all but one of the four evaporator bodies has been delivered. Completion of the fourth body was delayed by the recent steel strike, but delivery is expected soon. Technical data developed when the installation is working will be shared with the 13 Wisconsin sulphite mills in the Sulphite Pulp Manufacturers Research League.

Powell River

The largest pulp grinders in the world were installed at the Powell River Co. mill, Powell River, B. C., in May. The two new Waterous grinders handle 64-in. wood and were installed at an over-all cost of about $1,200,000. The production per stone is reported to range between 60 to 70 tons per day while the two-stone unit consumes about 9000 hp.

West Virginia

Major administrative changes in the Wood and Woodlands Depts. of West Virginia Pulp and Paper Co. have been announced.

M. H. Collet, formerly Assistant to W. J. Bailey, Vice-President, has been given a new assignment by the company to explore opportunities in Latin America. Duties formerly handled by Mr. Collet will be divided between D. Y. Lenhart, who has been Assistant Manager of the company's Southern Woodlands Office in Summerville, S. C., and P. T. Lannan, Jr., manager of the company's Westvaco Experimental Forest, near Andrews, S. C.

Mr. Lenhart is appointed general manager of woodlands for the company, with headquarters in the New York office. He has been assigned responsibilities formerly held by Mr. Collet with regard to management activities on company lands and the general pulpwood supply for company mills.

Mr. Lannan is appointed technical adviser to the Vice-President. In this capacity he will administer the Southern, Appalachian, and Northeastern forestry and pulpwood research projects of the company. He will divide his time between his present Westvaco Experimental Forest headquarters and the company's New York office.

West Africa

A Portuguese firm, Sociedade Ultramouna de Celulosa, is planning to construct a new pulp and paper mill in Angola, Portuguese West Africa. It is expected that the plant will take about 18 months to complete and initially, production will be confined to wood pulp.

China

Following experiments with a variety of materials during the past two years, the Chinese are now using bamboo, rice stalks, and stems of cotton plants to make pulp and expand the country's paper industry. The most important success so far has been with chihchi tsao, a kind of wild grass that grows along the Yellow River. Paper made from this grass is said to be "more resistant to folding and crushing than American banknote paper."

In spite of the most intensive efforts, however, China's paper industry is not yet able to supply more than a portion of the country's needs. At the Moscow Conference last April the Chinese delegates time and again listed paper and pulp among the commodities they were interested in buying from Western Europe. The literacy drive has led to all-time record newspaper circulations and demands for textbooks, novels, and Marxist works. Special attention has been paid to supplies of paper for cultural needs, and a government-backed committee is responsible for rationing paper at cheap prices for the press and publications.

Ketchikan Alaska Mill

American Viscose Corp. and Puget Sound Co.'s jointly owned Ketchikan Pulp Co. at Ward Cave has been allotted a section of the Tongass National Forest, containing an estimated 8,000,000,000 board feet for pulp production. It is said that the timber allotted to the company would be sufficient to sustain a 525-ton pulp mill in perpetuity, because of the rapid rate of timber growth. Present plans call for a 300-ton mill with virtually the entire production being contracted for by American Viscose Corp. for a period of 20 years.

Tall Oil

Tall oil is obtained from the pinewood used in making paper and so is a co-product of sulphate pulp. It contains from 38 to 58% rosin acids (resembling abietic acid), from 36 to 54% fatty acids (a mixture of unsaturated 18 carbon acids), and from 5 to 10% unsaponifiables (a mixture of sterols, higher alcohols, hydrocarbons, etc.).

Much of the whole tall oil is processed further to improve its color and odor, and to change its composition or other qualities. Consequently *refined* tall oils and *distilled* tall oils are produced in many grades for many purposes, ranging in color from pale yellow to dark brown, and in viscosity from that of thin motor oil to that of thick grease. Many processing operations shift the composition balance toward a higher fatty acids content.

Tall oil is used either as such or in the form of soaps, esters, and derivatives. Soluble soaps of tall oil include: soda, potash, ammonia, and amine. Metallic soaps include: cobalt, manganese, lead, iron, aluminum, zinc, and calcium. It is

HAM FELTZ says:

Down Time is Costly

An idle paper or board machine, like an idle horse, eats its head off. But, unlike a horse, a machine does not need to take time out for rest. Consequently some mills can afford to pay time-and-a-half for over-time labor. They make up the difference by the extra economy of continuous machine operation.

Not so with felts. Felts do get tired before they wear out. A tired felt can't remove as much water as a fresh felt can remove in a given time. When you have to reduce speed or to increase the heat at the driers you know that it is time to replace felts.

Year after year for almost a century, mill superintendents have been well satisfied with Hamilton Felts.

The Hamilton Sales Engineer will be glad to work overtime when you are ready to talk felts.

Hamilton Felts

MIAMI WOOLEN MILLS

Established 1858

SHULER & BENNINGHOFEN, HAMILTON, OHIO

converted into methyl, ethyl, and related esters and into esters of glycols, glycerol, sorbitol, pentaerythritol, and other polyalcohols. Various blown or oxidized tall oils are produced. It is sulphurized and also sulphonated.

Tall oil enters into the manufacture of the following materials:

Adhesives
Asphalt
  Emulsions
  Wetting agents
Binders
Boring oils
Cement addition agents
Cleansers
Core oils
Cutting oils
Disinfectants
Drawing oils
Emulsifiers
Factices
Flotation reagents
Fungicides
Gloss oils
Greases
Grinding aids
Linoleum
Mold lubricants
Oilcloth
Paint driers
Paint oils
Paper sizes
Penetrating oils
Pigment wetting agents
Plasticizers
Polishes
Printing inks
Resins
Rubber chemicals
Soaps
  Cakes
  Chip
  Dry cleaners
  Laundry
  Liquid
  Scrub
  Soft
  Textile
Soluble oils
Sulphonated oils
Textile oils
Varnishes
Waterproofing agents
Wetting agents

Road Binder

Felker Bros. Mfg. Co., Marshfield, Wis., is distributing an interesting 16-page booklet, entitled "For Better Roads." A copy is obtained on request. It tells the story of the use of spent sulphite liquor.

Institute of Paper Chemistry

Eleven new students at The Institute of Paper Chemistry arrived at the Trees for Tomorrow Camp, Eagle River, Wis., on August 17, to begin the Institute's annual bush course; they were accompanied by Dr. Irving H. Isenberg, Research Associate in Wood Technology, and Dr. J. Edward Todd, Dean of Admissions. The academic year for the class opened three days earlier with a series of examinations and orientation lectures by members of the administrative and teaching staffs.

The bush course includes instruction in the identification of northern forest trees, timber cruising, management of industrial forests, and operations of the United States Forest Service. The men also visited the Rhinelander Paper Co.,

Reading from left to right: Irving Isenberg of the Institute staff, Jack Chinn, David Most, Vincent Russo, Nicholas Jappe, Robert Hisey, Krishan Talwar, John Eisch, Robert Grothaus, Joseph Parker, David Gamber, and Leo Bernardin

The paper house at the Institute which was recently dismantled after standing 8 years

Consolidated Water Power & Paper Co., Mosinee Paper Co., and Neenah Paper Co. before they returned to Appleton on September 12.

The new student group, which comes from eight states and one foreign country and has graduates from twelve different colleges and universities, includes: Leo J. Bernardin, Lawrence, Mass., Tufts College; Jack E. Chinn, Des Moines, Iowa, Cornell College; John J. Eisch, Milwaukee, Wis., Marquette University; Robert F. Grothaus, San Antonio, Tex., University of Texas; Robert W. Hisey, Glens Falls, N. Y., Middlebury College; Nicholas A. Jappe, Anacortes, Wash., University of Washington; David S. Most, Cambridge, Mass., Boston University; Joseph D. Parker, Norfolk, Va., North Carolina State College; Vincent A. Russo, White Plains, N. Y., Rensselaer Polytechnic Institute; Krishan K. Talwar, Delhi, India, Khalsa College, Amritsar, India; and David A. Gamber (special student), Pelham, N. Y., University of Maine. Edward T. Turner, Jr., a special student from Dayton, Ohio, and a graduate of Cornell University, will arrive later.

The paper house, a point of interest on the grounds of The Institute of Paper Chemistry since 1944, was dismantled last week as construction operations were started in the area for the new General Activities Center.

The house, designed and developed at the Institute during the war, was a project for a government agency seeking an inexpensive, portable shelter for possible emergency housing in disaster areas. Specifications had included the requirement that the structure should last in virtually any climate for one year. When the house came down, it had just celebrated its eighth birthday. It survived 32 Wisconsin seasons—hot sunshine, protracted periods of rain and dampness, and subzero weather with its accompanying blizzards. Windstorms that damaged nearby trees had no visible effect on the house.

The unit, which had a floor area of about 8 by 16 ft., was made entirely from wastepaper prepared in the form of 2" impregnated chipboard panels painted with a fire-resistant paint and joined together by special metal connectors. No framing or studding was employed. The essential parts weighed slightly more than 1000 lb., could form a package as small as 4 by 8 by 2 ft., and were assembled into the completed house in less than an hour. An oil stove, operated for the first Winter, kept the house at a comfortable temperature with a reasonably low fuel consumption.

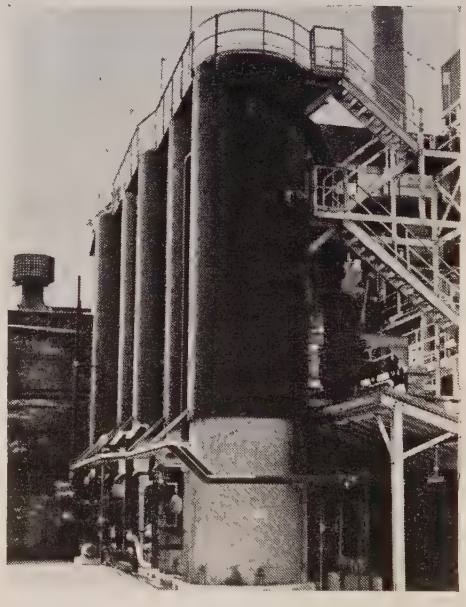
Though its design was based on probable manufacturing methods, this experimental house was a laboratory creation at the Institute. It was the only one produced. During its development a severe shortage of paperboard arose and continued for some time after the war; later the impregnating

See General American for
CREATIVE EVAPORATOR ENGINEERING

Indoors or outdoors —Use High Efficiency Conkey Integral* Evaporators

*Patented

Designed to do your job best!



With minor design changes the Conkey Integral Evaporator is adaptable to any plant location requirement without sacrifice of its improved design and operational features. The Conkey may be set outdoors and provided with skirts making it completely self supporting. It may also be set indoors with the skirts omitted and structural steel supports added, which are provided either by the building framing or independent columns.

These advantages are found in all Conkey Integral Evaporators regardless of final job details: (1) Easier to erect. (2) Needs less space. (3) Lower overall pressure drops. (4) Larger, more efficient entrainment separators. (5) Fewer mechanical joints to guard against air leakage.

Because its design reduces pressure drop losses between effects, the Conkey Integral Evaporator provides an increased working temperature drop across the heating element surface. Result: a net positive gain in evaporation—extra evaporating capacity. For complete technical information, write for Evaporator Bulletin.

Other General American Equipment:
Turbo-Mixers, Filters,
Dewaterers, Dryers,
Towers, Tanks, Bins,
Pressure Vessels

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agent, sulphur, became scarce. Consequently, a paper house was never available for emergency use, nor produced commercially. The research, however, that went into its development demonstrated its feasibility and stimulated the use of sulphurized board for other paper products.

The creation of a paper house attracted world-wide attention. Publicity released by the War Production Board shortly after the structure was erected brought several thousand inquiries to the Institute. Letters, cards, and telegrams requesting more details came from all parts of the United States. Correspondents from Sweden, France, Guatemala, Egypt, and China wanted to know where such a house could be purchased.

United Kingdom Paper Industry

Reliable sources believe that the present recession in the British paper trade will not develop into a major slump and may be followed by a revival of business in the Fall, when present high-priced stocks have been exhausted.

The demand for paper and paper products in the U. K. declined suddenly in the second quarter of 1952. On May 10 and July 3, 1952, the Ministry of Materials announced reductions on the resale price of certain grades of paper. . .in the hope that the cuts would act as an incentive to the buyers to purchase new stock.

As the quarter ended it was obvious that the cuts were having no effect, and the market continued extremely quiet.

Spain

Spain's production of pulp and paper during 1951 continued the upward trend initiated in the preceding year, although imports of pulp decreased considerably because of the scarcity of foreign exchange, and the paper mills operated below production capacity. Production increased from 169,800 metric tons in 1950 to 186,700 metric tons in 1951.

The Roman Empire

In Gibbon's "Decline and Fall of the Roman Empire" this item was found under the years 273 to 275 A.D.

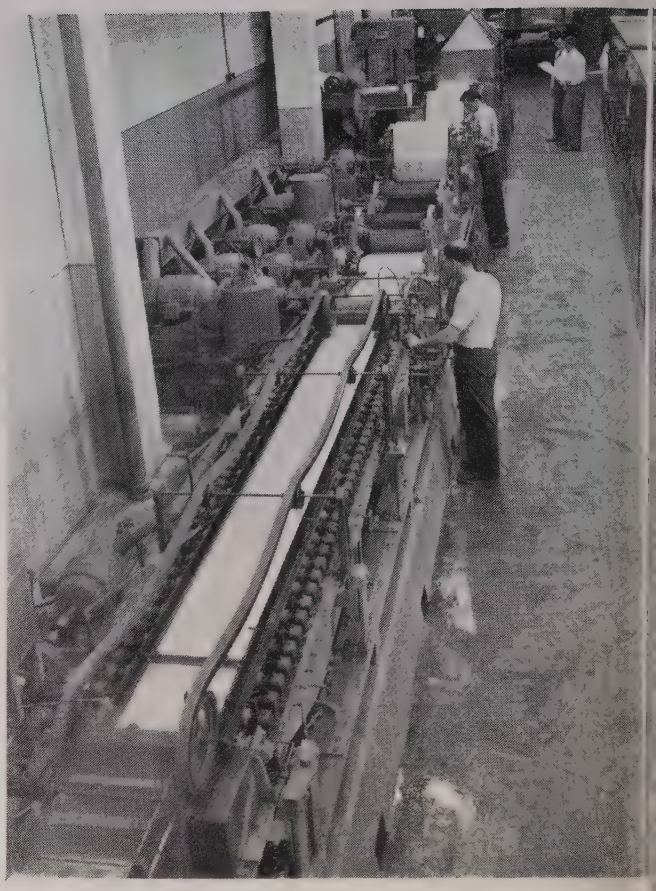
"Firmus, the friend and ally, as he proudly styled himself, of Odenathus and Zenobia, was no more than a wealthy merchant of Egypt.

"The Egyptians he inflamed with hope and freedom and, at the head of their furious multitude, he broke into the city of Alexandria, where he assumed the imperial purple, coined money, published edicts and raised an army, which, as he vainly boasted, he was capable of maintaining from the sole profits of his paper trade."

University of Flordia

The University of Florida has asked the state for a $100,000 wood pulp research laboratory and virtually guaranteed the research would eventually net Florida "millions of dollars." Dr. J. Hillis Miller, university president, told the state cabinet the school's research and experiments with Florida' scrub oak have led to development of a new kind of paper. The university also has developed a wood pulp that can be used in making various rayons and plastics, he added. "In our opinion," Dr. Miller said, "these developments have great commercial and economic benefits for the state. Eventually, we believe our research would return millions of dollars to Florida." Dean Joseph Weill, who has been leading the scrub oak experiments said the school has contracts totaling $365,000 for a continuing research, "if we just had a plant."

Various manufacturers and industries have loaned necessary equipment and money for further experiments, "but we can't take contracts for research because we need an enlarged laboratory," Weill said. The cabinet voted to appoint a committee to study a plan—suggested by Gov. Fuller Warren—which would ask Florida pulp and wood industries to finance part of the cost of building the laboratory. The state Internal Improvement Board could then finance part.



Experimental fourdrinier paper machine on which pamphlet stock for programs observing fiftieth anniversary of Nebraska National Forest was made at U. S. Forest Products Laboratory

Nebraska Forest

A man-made forest launched in the midst of Nebraska's desolate sand-hill country half a century ago has demonstrated that this barren land can furnish high-grade pulpwood if given the chance.

From the Nebraska National Forest has come the raw material for a high-grade printing paper that was produced in the experimental papermaking equipment of the U. S. Forest Products Laboratory. And that same paper was used for the printed programs issued for the celebration of the forest's fiftieth anniversary September 10–14.

The forest is a unit of the publicly owned chain of national forests managed by the Forest Service of the U. S. Department of Agriculture. Consisting chiefly of such pines as ponderosa, red, Scotch, Austrian, and jack, it came into being in 1902 largely because of the tireless efforts of a well-known botanist, Dr. Charles E. Bessey.

In the midst of west central Nebraska's white, dry sand hills, Dr. Bessey helped found a small nursery of pine seedlings. From that small start, a forest covering many thousands of acres has sprung up near Halsey, Neb. It is a forest complete with wild game, songbirds, fire towers, roads, and trails. For some years it has been a show window of what forestry can do even under such discouraging conditions.

The success of the forest was one reason why the vast shelterbelts of trees extending from the Dakotas to Texas were planted during the drought-stricken 1930's to help curtail dust storms and literally "hold the soil down." Many of these shelterbelt plantings have since also produced trees of marketable timber size.

Ponderosa pine pulpwood was used to make the program stock at the Forest Products Laboratory, which is maintained in Madison by the Forest Service. The pulp was made by the conventional sulphate process, which produces strong

THE FOURTH DICALITE PLANT

...will add approximately 80% increased production capacity for Dicalite calcined and processed filteraids and fillers

The new plant of the Dicalite Division, Great Lakes Carbon Corporation, at Lompoc, Calif., is now in volume production at a continually increasing rate. It represents over 5 years of engineering, design and construction, and is the largest complete unit for processing diatomite built in the last 22 years. Full designed output will add approximately 80% increased production capacity for Dicalite calcined and processed filteraids, fillers and other materials.

This increased production capacity insures a plentiful supply of Dicalite products for the future. Users can be confident of dependable delivery, with four plants in operation, chances of interrupted supply are greatly reduced.

Advanced design of the new plant has afforded greater operating flexibility and extended processing ranges. Specifications for performance and quality of each product are readily maintained. Research data are being accumulated to aid in developing new and improved Dicalite products for future industrial use.

DICALITE DIVISION GREAT LAKES CARBON CORPORATION

GLC

NEW YORK 17 • CHICAGO 1 • LOS ANGELES 17

Side-dumping truck recently purchased by the New York & Pennsylvania Co.

pulps for wrapping paper and containers from most species of wood.

A four-stage process was used to make a bleached pulp with good strength properties and high brightness value. The bleached pulp was processed in beaters and jordans and was made into a pamphlet stock about 0.008 in. thick on the Laboratory's experimental fourdrinier paper machine. The paper was tinted pastel green and water-marked with a the Forest Service seal. The narrow width of the machine made it possible to retain the natural deckle edges.

At the September celebration in Halsey, Neb., leading foresters from throughout the United States saluted the ingenuity and vision of the men who founded and nurtured the forest. Many foresters fresh from college and just starting in the Forest Service have learned over the years how trees are grown by planting seedlings by hand in those hot sand hills.

New York and Pennsylvania

The New York & Pennsylvania Co., Inc., plant at Lock Haven, Pa., has recently purchased an Easton side-dump truck body designed and built to handle wood from the wood ranks to the hopper. Powered side-dumping, which eliminates the manual unloading method used at some mills, will speed the entire cycle of pulpwood handling. Side-dump truck bodies of this type may be mounted on any suitable truck chassis. While the new body has not yet been put into service at Lock Haven, the efficiency of side-dumps in other fields of off-highway hauling indicates a positive saving in time and man power, and a considerable increase in volume handled.

The truck body is the Easton Model BD-2112H manufactured by Easton Car & Construction Co. of Easton, Pa. The body is of all-welded steel construction and features a patented automatic down folding side door. This down folding door is lowered by the jacks that tilt the body sufficiently in advance to assure some of the load spilling before the body itself is tipped. This preserves stability of the unit whether loaded, partly loaded, or empty. When the body is raised for dumping the door becomes flush with the floor, forming a chute which discharges the load into the hopper. Dumping is accomplished by means of hydraulic telescopic hoists located at each end of the body and controlled from the cab. Capacity of the body is rated at 21 cu. yd. or 12 tons of pulpwood.

Side-dumping trucks are preferred over conventional rear-dump trucks because the former do not require turning and backing at the discharge point. The driver is able to see where he is going at all times. The haulage route is a loop to the hopper and back to the wood ranks, establishing a continuous production line for handling the pulpwood. The use of trucks also provides complete flexibility in establishing or changing the loading point.

General License

Press reports from Washington state that the Office of International Trade has now placed all exports of paper-making grades of wood pulp to all countries (except the Soviet Union and its satellites) under "general license" without prior application to the OIT.

Federal Bureaus

The Federal land empire, involving 40 agencies of Government, now control 455,146,726 acres or 711,166 sq. mi. These vast holdings, equaling three acres for every man, woman, and child in the United States, are equal to the combined area of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, Pennsylvania, Delaware, New Jersey, Maryland, and the District of Columbia. The Federal holdings vary from state to state, with only one quarter of one per cent in Iowa to 69% in Arizona, 71% in Utah and 85% in Nevada.

Sixty per cent of the nation's timberland is under Federal ownership, with 16 different agencies controlling these lands. The Government now has its eye on 35 million additional acres, having taken over 45 million acres in the past three decades.

Tree Farms

The latest tabulation on tree farms released by the American Forest Products Industries, Inc., on August 1, shows that tree farms now cover 26,084,485 acres. Alabama has the largest number of tree farms, 404, with an acreage of 2,593,950 acres. Texas has the greatest acreage devoted to tree farms: 3,203,720 acres, on 395 farms.

H. P. Smith

H. P. Smith Paper Co., Chicago, Ill., manufacturers of flexible barrier materials, has completed installation of its third thermal resin coater. The new unit is capable of coating speeds up to 1000 f.p.m. with a coating thickness range from 0.0005 to 0.01 in. Currently it is applying polyethylene coatings, but other types of thermal plastic coatings have been successfully run. Designed by the H. P. Smith engineering staff, this unit has many patented features making possible close control and uniformity of coating weights. Fabric, board, and foil webs are currently being coated, as well as paper.

Capacitor Paper

"Measurement of the Thickness of Capacitor Paper" by Wilmer Sander and S. B. Newman has been issued by The National Bureau of Standards, Washington, D. C. (NBS Circular 532). It may be obtained from the Government Printing Office, Washington, D. C., for 15 cents. The circular discusses the three methods used: (1) direct observation across the edge section by means of a micrometer microscope, (2) measuring the separation of two geometric surfaces between which one or more specimens are placed, and (3) determining the mass of a definite area of sample and computing the thickness by means of density parameter. The circular contains a statistical analysis of the results obtained in a number of laboratory measurements.

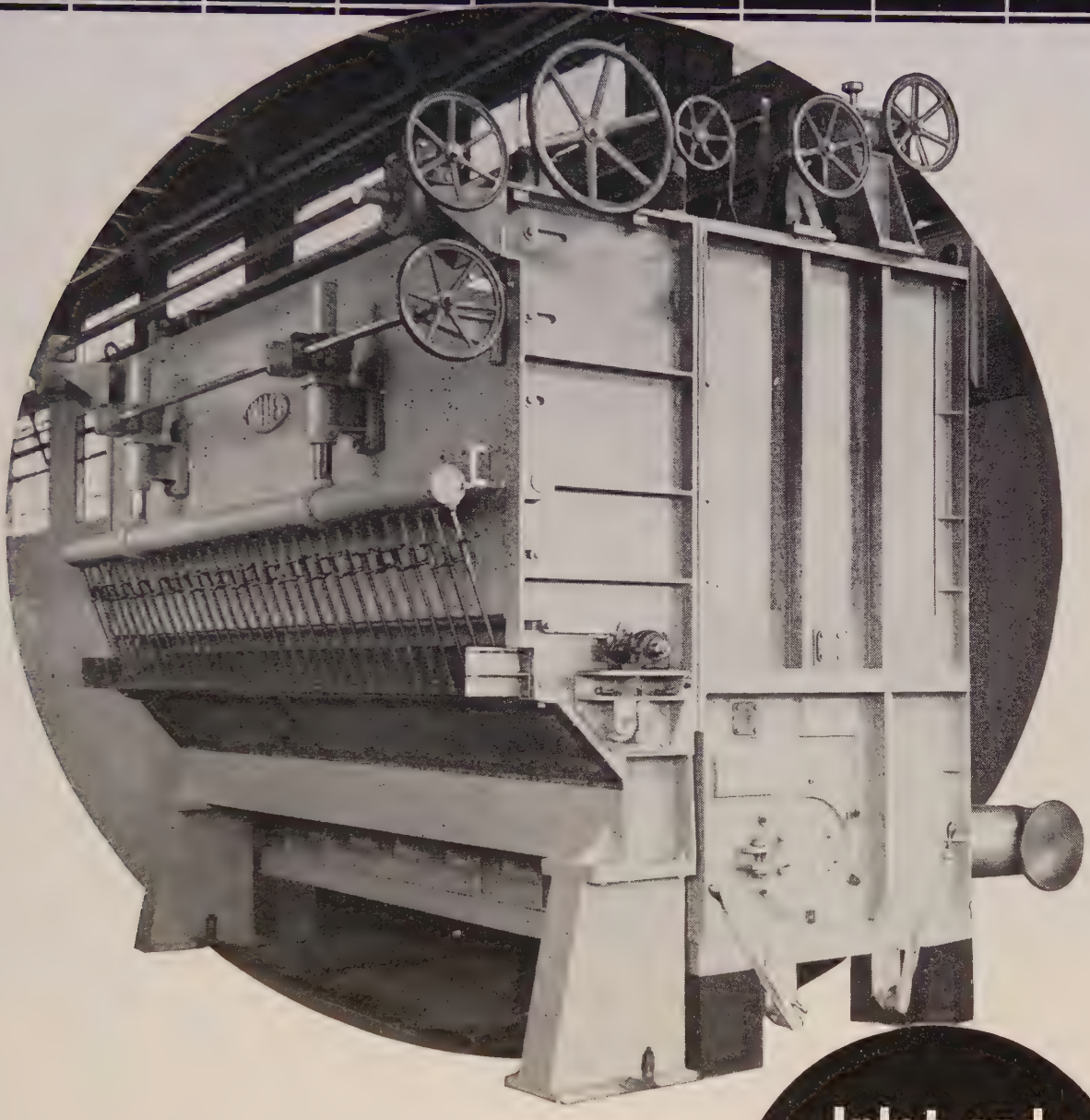
Rayonier

Walter Thad McDaniel, formerly Secretary to Senator Walter F. Georgia, has been appointed Public Relations Manager for Rayonier, Inc., Southeastern operations. He will be located at Jesup, Ga., site of the company's fifth and newest cellulose mill which will be completed in 1954. It will have a capacity of 87,000 tons.

N. Z. Forest Products

N. Z. Forest Products Ltd. will soon be operating New Zealand's first kraft paper mill at Kinleith. The output will be sufficient for most of the Dominion's present requirements. The new paper machine will produce 104 tons per day.

QUICK DIVIDENDS



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The purpose of this brief treatise is to place before executives of the smaller paper mills information it is believed will be helpful to them in evaluating the importance of proper traffic management in relation to production, and to suggest, in general, ways and means of increasing their efficiency and reducing their transportation costs.

Business executives of the passing and present generations have bent their efforts mainly toward solving the problems of production and manufacture. In this development, other phases of business, including industrial traffic management, have not always received the same thought and effort.

American industry spends 50 billion dollars annually for transportation. The paper and paperboard industry pays approximately $700,000,000 a year to the transportation industry to haul its inbound raw materials and its outbound manufactured products.

Although the Interstate Commerce Act provides that it is unlawful for common carriers to make, give, or cause any undue or unreasonable preference or advantage to any particular company, locality, etc., or to subject any particular company, locality, etc., to any undue or unreasonable prejudice or disadvantage in any respect whatsoever, it usually requires an expert traffic manager or consultant to discover a violation of such provision.

The big shippers, with few exceptions, are traffic minded. Suffice it to say they now have well-organized traffic departments managed by top-notch traffic managers who devote their full time to transportation matters.

Fortunately, the smaller shippers reap the benefit of the activities of these traffic managers who devote much of their time to fostering projects of considerable value to all shippers, big and small alike.

However, specific traffic problems make it necessary for each paper mill to give some attention to this phase of its business.

Unfortunately, many of the smaller mills overlook the importance of traffic management and neglect to give any attention to their transportation problems, except to complain about the dollars and cents increase in their freight bill.

The American Paper and Pulp Association has had an active Traffic Committee for many years and since 1946 its staff includes a full-time Traffic Executive. This committee has earned the respect of the industry, the Interstate Commerce Commission, the executives of the railroads, and other transportation agencies. About 40 of the leading traffic experts of the paper industry serve on this committee and give freely of their time and energy to help solve the major transportation problems of the industry as a whole.

Although it is not feasible to report everything the Traffic Committee does, suffice it to say that it is ever alert to protect the general interests of the paper industry.

The Traffic Committee of the American Paper and Pulp Association watches general developments in the transportation field and after consideration acts with respect to such items as:

Transportation legislation
General increase freight rate cases (*Ex Parte* proceedings)
Rules and regulations
Freight classification and uniformity of descriptions
I.C.C. Service Orders
Claim prevention
Loading rules
Simplification of tariffs
Statistics

and many kindred subjects. Individual, local, or sectional traffic problems, however, are not within the scope of the Traffic Committee's authority or activity.

It is recognized that the production of some mills is not large enough to warrant the employment of a full-time traffic manager. The executives of some such smaller mills, however, recognize the importance of and need for traffic advice and administration. In order to obtain it they join with other mills in sponsoring traffic associations, such as the New England Paper and Pulp Traffic Association and the Wisconsin Paper and Pulp Manufacturers' Traffic Association, which, as their names imply, serve member mills in the New England States and in the State of Wisconsin, respectively. Many of the larger mills in those areas also support these associations and together they protect the general and specific traffic interests of their members.

Where similar associations are nonexistent, some mills find it expedient to engage a traffic consultant (one who serves many diversified industries), who handles some of their traffic problems, such as rate and routing quotation and adjustments, also the auditing of freight bills. There are numerous reliable and competent traffic consultants located in all sections of the Unites States, who may be engaged on an annual or monthly basis, or to handle one specific problem, for a specified fee.

In some cities, the Traffic Bureau of the local Chamber of Commerce performs some of these functions.

Although the local freight agents are often very helpful, and it is well to cultivate their friendship, shippers should not rely on them or other railroad employees for all of their traffic information.

Traffic management is not static—changes occur from day to day, which must be studied. Although many transportation operations apply uniformly to all shippers, no two mills have identical traffic problems. To obtain the best results, the person responsible for handling traffic problems must not only have a working knowledge of the commodities manufactured, where produced, the markets served and other available markets, competition involved (competition with similar commodities, competition with other commodities, and the location of such competition) but must be thoroughly familiar with such items as:

Classification
Rates
Minimum weights
Minimum charges
Bills of lading
Routing
  Standard rail
  Differential rail
  Rail and water
  Barge
  All-water
Motor truck
  Common carrier
  Contract carrier
  Private carrier
Mixed carload rules
Pool cars
Demurrage
Loading
Claims
  Overcharge
  Loss and damage
Sources of raw materials and terms of purchase
Interstate Commerce Act
Warehousing
Materials handling
Stop-off cars for loading and unloading
Rules and regulations
Methods of packing
Railroad sidings
Truck loading and unloading platforms

Some of the important data required to obtain current information are:

Tariffs (in which freight rates are published)
Classifications (commodity descriptions and ratings)
Interstate Commerce Act (the law)
"Freight Traffic Red Book" (important traffic information)
"Traffic World" (general transportation—published weekly)
"Transport Topics" (motor carrier transportation—published weekly)

The Shippers Advisory Boards are a source of useful transportation information. Membership in one or more of the 1 regional boards is available to all shippers without cost as no dues or other charges are assessed and free distribution is made of the printed proceedings of meetings.

The need for traffic administration is not dictated by the size of the mill. The problem of the small mill is to secure adequate traffic administration at a cost within its means. If it is not feasible to maintain its own traffic department, or even a full-time or part-time traffic manager, the use of the services of outside traffic bureaus should be given serious con-

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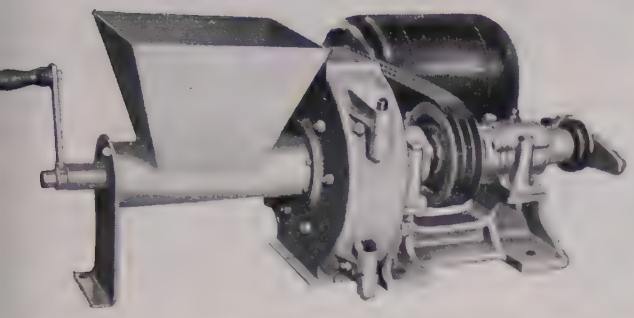

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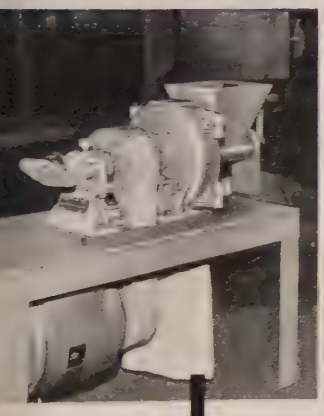

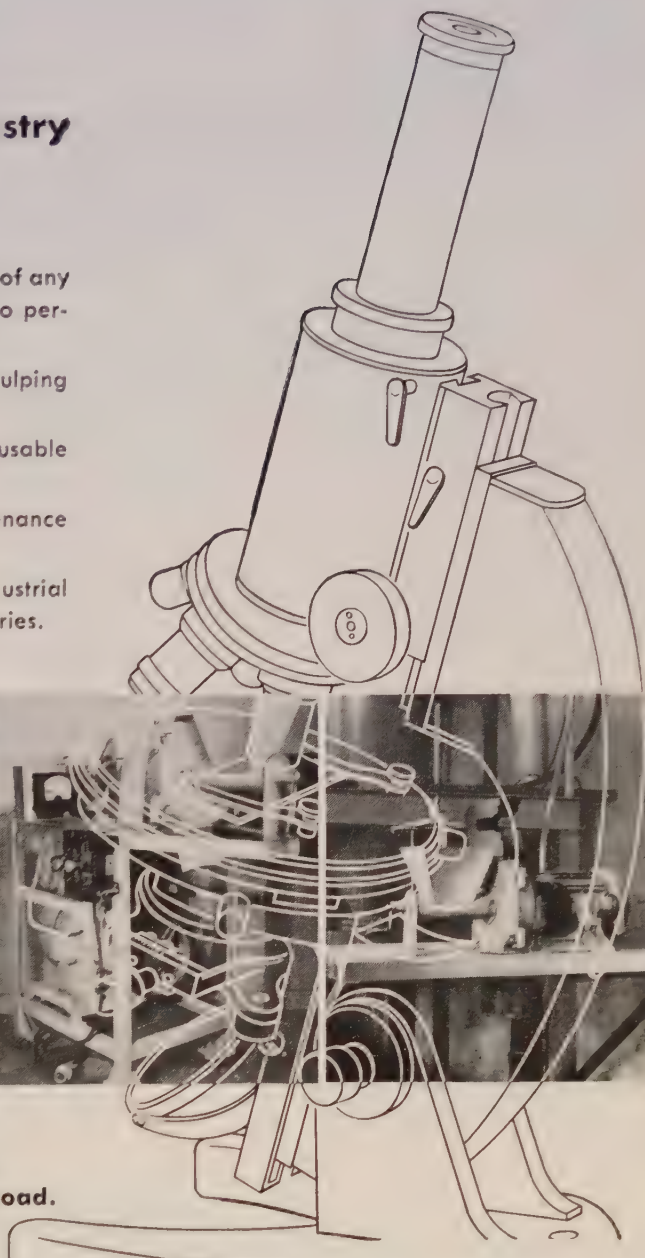

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PULP REFINERS

MUNCY, PA.

sideration by the small mill. Traffic administration of some kinds, and to some extent, can safely be delegated to an outside traffic bureau or consultant for handling; but at the same time, it is advisable that some executive within the mill should understand the concepts of traffic administration in order to follow and appreciate the work of the outside agency.

If what is written above, which of necessity is very brief, prompts a more favorable attitude toward traffic management by the executives of the mills, especially the smaller ones, not now traffic-minded, it is reasonable to assume that the results will be beneficial to such mills.

Finnish Cellulose Union

The first foundations leading to the establishment on July 2, 1918, of the Finnish Cellulose Union were laid at the meeting convened in Helsinki on Dec. 6, 1917.

In addition to the founders, all the other then existing cellulose mills in Finland joined the Union. They were 20 in number at that time and their total production in 1918 amounted to 19,944 tons of sulphite and 2328 tons of sulphate cellulose.

According to the agreement on the coalition the Union's object is to sell the cellulose production of its member mills at home and abroad. Besides this main task the Union has also participated in the marketing of the by-products of the cellulose industry, i.e., sulphite alcohol, tall oil, turpentine, etc., partly as a seller and partly as the joint central organ of the mills for these questions. In order to promote the quality improvement of cellulose the technical department of the Cellulose Union has worked in close cooperation with the technical staff of the country's cellulose industry. This activity has been closely associated with the work of their joint central laboratory.

The vigorous expansion of Finland's cellulose industry in the past years is also reflected in the quantities marketed by the Union. The attached graphs illustrate this clearly.

Today all Finnish cellulose mills, 27 in number, are members of the Cellulose Union.

The joint productive capacity totals approximately 1,500,000 tons per annum of which about 1,100,000 is export pulp.

The members of the Board of Directors are:

H. Gullichsen, Chairman, Niilo Kanto and Wm. Lehtinen, Vice-Chairmen, K. E. Ekholm, Paavo Honkajuuri, Jacob von Julin, Lauri Kivinen, R. Erik Serlachius, J. W. Walden, Stig Weckman, Sven Hägerström.

The Managing Director is Sven Hägerström, and other directors are Jaakko Rautanen, Allan Franck, T. Lassenius (Technical Director), and R. A. Ölander (Shipping Manager).

The member mills are at present:

Mill	*Firm*
Sulphite Pulp	
Ahlström (Warkaus)	A. Ahlström Osakeyhtiö
Eklöf	Aug. Eklöf Aktiebolag
Enqvist (Sphinx)	Aktiebolaget J. W. Enqvist Osakeyhtiö
Enso-Gutzeit, Tainionkoski (Torna)	Enso-Gutzeit Osakeyhtiö
Haarla	Haarlan Selluloosayhtiö
Jakobstad	Jakobstads Cellulosa Aktiebolag—Pietarsaaren Selluloosa Osakeyhtiö
Kajaani	Kajaani Oy.
Kaukas	Aktiebolaget Kaukas Fabrik
Kemi	Aktiebolaget Kemi Osakeyhtiö
Kuusankoski, Kymmene Woikka	Kymin Osakeyhtiö—Kymmene Aktiebolag
Nokia	Nokia Osakeyhtiö—Nokia Aktiebolag
Rauma	Rauma-Repola Oy.
Rosenlew	W. Rosenlew & Co., A.B.
Serlachius	G. A. Serlachius Oy.
Toppila	Osakeyhtiö Toppila
Veitsiluoto	Veitsiluoto Osakeyhtiö
Wärtsilä, Äänekoski	Wärtsilä-Cellulosa Ab.
Yhtyneet, Ilves	Yhtyneet Paperitehtaat Osakeyhtiö
Yhtyneet, Walkiakoski	
Sulphate Pulp	
Enso-Gutzeit, Kaukopää (Seal)	Enso-Gutzeit Osakeyhtiö
Enso-Gutzeit, Kotka (Gutzeit)	
Joutseno	Joutseno-Pulp Osakeyhtiö
Kemi	Aktiebolaget Kemi Osakeyhtiö
Lohja	Lohja-Kotka Oy.
Oulu	Oulu Osakeyhtiö
Sunila	Sunila Osakeyhtiö

KVP

Dwight Stocker, formerly President of the Michigan Paper Co., is now President of the Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich. Alfred Southon was elected to the Chairmanship of the Board.

Canada

More than 77% of the output of the Canadian pulp and paper industry now running 9.6 million tons, moves abroad. Following is a record of the industry's growth.

Year		*Pulp and paper mills*	*Total mill employees*	*Total production*
1871		21	760	$ 1,071,651
1881		41	1,588	2,509,993
1891		58	2,817	3,633,257
1901		53	6,236	8,627,557
1911		72	9,766	23,266,479
1921		100	24,619	151,003,165
1931		103	26,669	174,733,954
1941		106	37,154	334,726,175
1951	Estim.	130	55,000	1,200,000,000

Consolidated

Two new on the machine-coated offset grades have been announced by the Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis. The new papers, which are the first of their type to be made by the company, will be called "Productolith" and "Consolith."

Scott

Arthur F. Armstrong has been named Personnel Manager for Scott Paper Company's West Coast operations. He will be located at Soundview, Wash., and will be responsible for the administration of the personnel program at Soundview, Empire, Ore., Anacortes, Wash., and Coos Bay.

Gair

Robert Gair Co. has moved its suit and retail box manufacturing department to its Thames River plant at New London, Conn. For 30 years, Gair has been supplying retail boxes for the New England area from its plant at Natick, Mass.

Crown Zellerbach

Crown Zellerbach Corp. has sold its new one-story converting plant and office building at 3416 Garfield Ave., Los Angeles, Calif., to the Mutual Life Insurance Co. of New York. Mutual has leased the building back to Crown Zellerbach for 25 years with the option of renewing for another 5 years. The building contains 68,700 sq. ft.

Strathmore and Hawthorne

The Strathmore Paper Co., West Springfield, Mass., has advanced H. Paul Kimball to Manager of Mill Sales to replace Nelson Feeley who has resigned to become General Sales Manager of the Hawthorne Paper Co., Kalamazoo, Mich.

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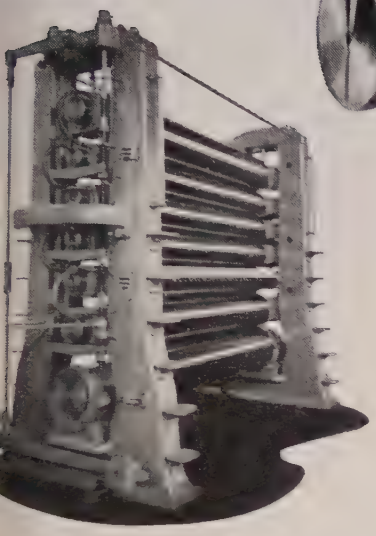
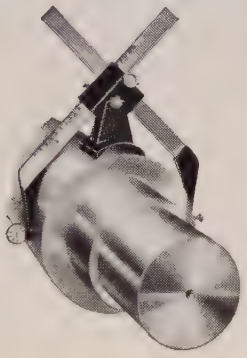


CHILLED IRON AND ALLOY CHILLED IRON ROLLS

Lobdell Plain Chilled Iron Rolls have a uniformly hard surface highly resistant to abrasion and deformation under load. They give longer service for machine calendering. Alloy Chilled Iron Rolls for water finish or high pressure stacks are harder and more resistant to corrosion and abrasion than ordinary rolls.



MICROMETER ROLL CALIPERS

Light weight permits easy handling by one man, and they are readily adjusted to a wide range of roll diameters. Micrometer dial is graduated in thousandths.

MACHINE CALENDER STACKS

Lobdell high speed Machine Calender Stacks combine heavy rugged construction with very easy operation. Long service life and constant accuracy are inherent in Lobdell Stacks. Bearings may be plain or water-cooled, babbitted or bronze lined—or anti-friction. Rolls are Chilled Iron for ordinary machine Calendering or Alloy Chilled Iron for water finish, or on high pressure stacks. Pressure is applied to journals of top roll through an effective system of weights and levers . . . lifting arrangement is controlled from the floor by ratchets, electric motors or hydraulic cylinders.

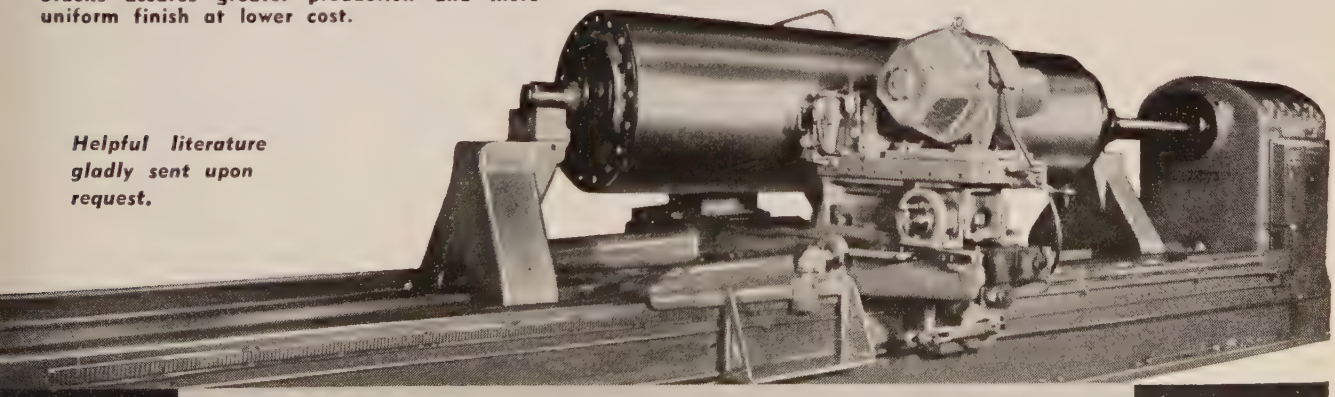
The accurate, durable construction of Lobdell Stacks assures greater production and more uniform finish at lower cost.

ROLL GRINDERS

Rugged, extremely accurate, with ease and flexibility of operation . . . these huge LOBDELL Type CW Roll Grinders are a proper supplement to the giant paper machines of today. Designed for Direct Current operation, but for connection to an A.C. power supply, the LOBDELL Type CW has a heavier, more massive wheel carriage and grinding wheel head construction . . . and the rigidity and capacity necessary to handle rolls up to 48" or 60" diameter, weighing 40 tons or more.

Other LOBDELL Grinders, Type GHV for A.C. operation are made in three smaller sizes to suit the requirements of any mill.

Helpful literature gladly sent upon request.



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1952

Plant Maintenance

Sixty-six sessions will feature the Plant Maintenance Conference which will be held at the Public Auditorium, Cleveland, Ohio, on Jan. 19–22, 1953.

Florida Conference

The First Annual Pulp and Paper Conference presented by the Pulp and Paper Laboratory of the University of Florida was held at Gainesville, Fla., on Sept. 8–12, 1952. The conference was held to develop broader technical knowledge in tour foremen who have already shown qualities of leadership. The subjects and speakers were:

"The General Picture," by Franklin L. Jones, Assistant to the Production Manager, St. Joe Paper Co., Port St. Joe, Fla.
"Preparation of Chips," by Rudolph C. Richter, Pulp Mill Superintendent, St. Marys Kraft Corp., St. Marys, Ga.
"Digester Room Equipment," by E. A. Harper, Pulp Mill Superintendent, Hudson Pulp and Paper Mill, Palatka, Fla.
"The Cook and His Duties," by Malcolm Pineo, Technical Director, Brunswick Pulp and Paper Co., Brunswick, Ga.
"The Sulphate Process (The Four Periods)," by Dr. W. J. Nolan, Pulp and Paper Laboratory, University of Florida.
"The Employee Relationship," by J. A. Berg, Industrial Relations Director, Hudson Pulp and Paper Corp., Palatka, Fla.
"Digester Instrumentation," by Steve Kennedy, Minneapolis-Honeywell Regulator Co., Jacksonville, Fla.
"Control Tests (Two Periods)," by Dr. Peter B. Borlew, Technical Superintendent, Container Corp. of America, Fernandina Beach, Fla.
"Physical Testing of Pulp," by Milton Roberts, Chief Chemist, St. Regis Paper Co., Jacksonville, Fla.
"An Alkaline Pulping Conference," by Dr. Wilson F. Brown, Pulp and Paper Laboratory, University of Florida.

Canadian Tree Farm

The importance of an assured wood supply has made large-scale farmers of all the big paper concerns. Canadian International Paper recently opened a forest farm of 3000 acres in Quebec which included a demonstration project for woodlot owners. International has nearly 18,000,000 acres of owned or leased timberlands. Champion Paper planted 2,000,000 seedlings on company lands in the last year, bringing total plantings in the last five years to 17,000,000 trees. Kimberly-Clark will set out 2,000,000 trees in the next 12 months.

Kimberly-Clark

Penn Paper Co. of Harrisburg, Pa., has been appointed distributor of K-C printing papers. The firm will handle four grades: Hifect Enamel, Trufect, Lithofect Offset Enamel, and Multifect, which cover a range of coated and enameled papers for offset and letterpress printing.

Vanillin

The decade shortage of vanillin will soon be over. Eugenol and guaiacol processes are falling by the wayside as more producers switch to lignin from spent sulphite liquor. It is expected that the added production may bring about a lowering in the present $3.00 per pound price for vanillin from sulphite liquors.

Monsanto Chemical Co., the top vanillin producer, has run the gamut of vanillin processes. In 1904 it started turning out vanillin from eugenol; by 1929 the company switched to the guaiacol synthesis. Monsanto is now switching to the lignin process. It is already producing semirefined vanillin at its new Seattle, Wash., plant.

In addition to being a flavoring agent, vanillin is used in silver plating, chemical intermediates, industrial odor masking, zinc plating, fungicides, and insecticides.

Weyerhaeuser

The Weyerhaeuser Foundation has established a $100,000 memorial fund at Yale University in honor of Charles S. Chapman who died in 1940, having been Chief Forester of Weyerhaeuser for 16 years. The fund will be used for the advancement of industrial forestry through fellowship grants, research, and other educational activities.

Turpentine Oil

The development of a high-quality synthetic lubricant made from turpentine has been announced by the Naval Research Laboratory.

Researchers have discovered that turpentine yields an acid similar chemically to that derived from castor oil and used to make high-quality lubricants.

For much specialized lubrication, synthetic lubricants do a better job than oil from the ground. A derivative of castor oil has been used for years, but 90% of castor beans are imported.

The new synthetic lubricant can be derived either from gum spirits of turpentine, a product of the living pine, or from sulphate wood turpentine, which is prepared from condensates recovered in the wood pulp cooking process.

Oxford

Oxford Paper Co.'s four-year scholarship at the University of Maine for the first time has been awarded to two students.

Both Eugene Arsenault and Paul Jones, Rumford, Me., will receive the full award.

The Oxford Paper scholarship provides a four-year college education in the fields of mechanical, chemical or electrical engineering as related to the manufacture of pulp and paper. Payments under the scholarship defray tuition and fees and expenses for books and supplies needed in the course. All courses are taken in the College of Technology.

M. & O.

The first meeting of the newly reorganized Executive Research Committee of the Minnesota & Ontario Paper Co. met at its Minneapolis office on August 6. The members of the new committee are: Robert Faegre, Chairman, J. H. Davidson, J. B. Faegre (*ex officio*), Clarence Larson, J. F. MacKellar, C. T. McMurray, M. S. Wunderlich, H. A. Hull, Secretary.

The function of the Executive Research Committee is to formulate over-all research policy and evaluate all research projects.

In Chairman Robert Faegre's words, "As time goes forward, the successful development and growth of the company will unquestionably depend more and more on an effective research program. However, research can only be effective if management accepts its full share of responsibility." In order to obtain the greatest possible participation of management from all phases of the company's operation, certain meeting procedures have been revised.

Under the new plan, ERC progress report meetings, previously held every 60 days, will be held coincidentally with the ERC work program meetings, which are scheduled at the beginning of each calendar quarter. This will permit more cohesive and comprehensive consideration of each research project with respect to progress during the preceding quarter, current status, and future work. The regularly scheduled meetings will be divided into two distinct parts, the first involving paper, pulp, and by-product matters only, and the second involving Insulite only.

From time to time, non-ERC members may be invited to participate. For paper, pulp, and by-products these will include R. A. Campbell, W. H. Schlafge, and P. W. Bartholomew; for Insulite, M. C. Fairfield, and F. E. Boeckh. Except for the substitution of U. L. Plain for M. C. Fairfield, all of these men attended the first meeting. Cliff Larson assisted Mr. Wunderlich at the meeting.

Interim ERC meetings will be called as required to take management action on individual projects that have been brought to a successful conclusion and are ready for commercial adaptation. Appropriate research project leaders will be invited to these meetings in addition to interested staff members.

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Only SOLVAY offers a *specialized* paper makers' Technical Service manned by skilled technicians who are experts in the paper field.

PROMPT DELIVERY FROM CONVENIENT POINTS

SOLVAY is equipped to serve you without delay from its centrally-located producing plants . . . thirteen branch sales offices . . . and a widespread chain of warehouses and stock points located right in paper-making areas.

QUALITY AND DEPENDABILITY

SOLVAY has served the paper industry for over sixty years—longer than any other alkali manufacturer! This vast accumulation of knowledge and experience tells you that you can depend on SOLVAY for quality paper-making chemicals.

SOLVAY
Alkalies Chemicals
Since 1881

SODA ASH

CAUSTIC SODA

LIQUID CHLORINE

SOLVAY PROCESS DIVISION
ALLIED CHEMICAL & DYE CORPORATION
61 Broadway, New York 6, N. Y.

Du Pont

The main West Coast office of du Pont's Dyes and Chemicals Div. has been moved to 845 E. 60th St., Los Angeles, Calif., with A. J. Mease, Manager. Customers in the San Francisco area may continue to direct inquiries to 111 Sutter St., and customers in the Pacific Northwest to 1238 N. W. Glison St., Portland, Ore.

General Electric

A new gear motor, designed to simplify maintenance in case of electrical failure of the stator, has been announced by G.E.'s Small and Medium Motor Dept.

Allis-Chalmers

Allis-Chalmers Mfg. Co. has organized a field group to provide A-C's general machinery division customers throughout the country with a maximum of fast and efficient service. C. W. Smeers, Vice-President and Director of Sales, will direct this service. It will handle all service, repairs, breakdowns, and adjustments in the field. Regional service supervisors named under the new setup are: B. F. Ureda, Chicago, midwest region; A. S. Hill, Cleveland, central region; D. T. Thomas, New York, empire region; C. P. Suykerbuyck, Atlanta, southeast region; E. G. Kime, Dallas, southwest region; and D. W. Seagrave, San Francisco, Pacific region.

Valley Iron Works

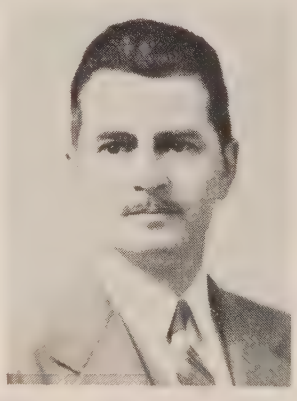
Richard U. Temple has joined the Sales Engineering staff of the Valley Iron Works, Appleton, Wis. Mr. Temple was formerly with Downingtown Mfg. Co., and Moore & White Co.

Technical Advertising

Lack of factual information, according to the monthly bulletin of Di Cyan & Brown, 12 E. 41st St., New York, N. Y. Often overlooked is description of product, how it works, why it is necessary or convenient. Unrelated matter, exaggerations, emotional appeals can often unsell technically trained buyers.

Sandoz

E. P. McGinn has been appointed head of the new Paper Div. of the Sandoz Chemical Works, Inc., 61 Van Dam St., New York, N. Y. Sandoz manufactures colors and chemicals. Mr. McGinn was recently a member of the editorial staff of the *Paper Trade Journal.*



E. P. McGinn, Sandoz Chemical Works, Inc.

Leeds & Northrup

The Philadelphia district sales office of Leeds & Northrup Co., manufacturers of electrical measuring instruments and automatic controls, has moved from 4901 Stenton Ave., to 444 N. 16th St.

E. D. Jones

E. D. Jones & Sons Co., Pittsfield, Mass., has issued an interesting 6-page bulletin (EDJ-1037) on its cartridge-type agitators for paper stock. Included are working drawings of chest designs, and a table of weights, volumes, etc., of pulp stock suspensions carrying various percentages of air-dry stock. Jones has also issued a 4-page brochure featuring the facilities and equipment of its fabricating plant.

Polyethylene

Polyethylene is now in ample supply. During the past year, producers have approximately doubled capacity. Polyethylene is difficult to make, requiring reaction pressures of more than 1000 atm. The reaction is one of the most exothermic known. The raw material must be practically untainted with anything else, especially acetylene. It is expected to become the most important plastic, volume-wise. The present output is about 125 million pounds. It is used in the paper industry for lining bags and coating fiber drums. The principal producers at present are du Pont and Union Carbide. It takes about 20 million dollars to build a polyethylene plant.

Wyandotte

Wyandotte Chemicals Corp., Wyandotte, Mich., have announced new facilities for manufacturing Carbose, a sodium carboxymethylcellulose. The main applications are at the calender stack in the paper and board industry. A new 40-page booklet, describing in detail the current Carbose series is available upon request.

International Nickel

The International Nickel Co., Inc. (Dept. E.Z.)., 67 Wall St., New York 5, N. Y., has issued a new 20-page bulletin "Modern Trends in Gear Materials." Recently developed ductile iron is evaluated as offering a new material that combines many of the advantages of steel and gray iron.

Harris-Seybold

Harris-Seybold Co., Cleveland, Ohio, has elected three new Vice-Presidents: Ben R. Perry, Vice-President for Sales; Harry A. Porter, Senior Vice-President, W. Ray Spilleh Vice-President, Engineering, and George C. Houck, Vice-President for Operations.

Lockport Felt

William W. Campbell, Jr., has been appointed Sales Manager of the Lockport Felt Co., Newfane, N. Y., succeeding the late Bertram A. Audley.

D. J. Murray

D. J. Murray Mfg. Co., Wausau, Wis., has announced a new hydraulic roll lowering table to prevent paper roll damage. Its use eliminates other complicated unloading tables or overhead hoist arrangement.

Standard Oil (Ind.)

Standard Oil Co. (Ind.) has started production of sulphuric a new plant at Whiting, Ind. Most of the 55 tons per day sulphur will be converted to sulphuric acid and used at the refinery. The new plant will extract hydrogen sulphide from by-product fuel gases produced in the Whiting refinery and convert it to sulphur of 99.9% purity. Plants of this type will aid materially in alleviating the critical shortage of sulphur.

Manhattan Rubber

Raybestos-Manhattan, Inc., has opened a new warehouse in Denver, Colo., to carry local stocks of packings, transmission belts, hose, etc. Elton T. Fair, Jr., is in charge of the new warehouse.

J. O. Ross

J. O. Ross Engineering Corp., 444 Madison Ave., New York 22, N. Y., has opened a new office at 823 Skinner Building, Seattle, Wash. K. H. Jones will be in charge of the new branch where he will supervise the design and installation of Ross air systems, industrial ovens, driers, and heaters.

The company has issued three informative bulletins to acquaint production men of the real meaning of the term "Air Processing."

MAGNUS-MADE

FABRICATED THIN-SHEET SCREEN PLATES

for High Plate Capacity—Long Plate Life

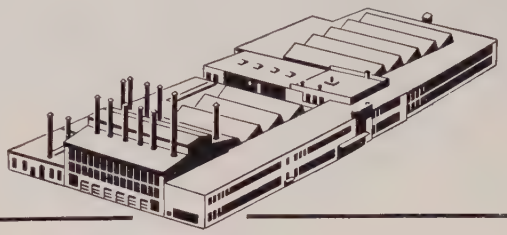
"Hardy" fabricated screen plates, made by Magnus of chrome-nickel-steel or inconel, have a high-strength, thin sheet design that's specially engineered for *maximum flow*. About 40,000 of these plates are now in service, with performance records that prove these three important advantages:

1. Increased Plate Capacity. The thin sheet eliminates relief milling, and with recommended arrangement, substantially increases capacity per plate.

2. Longer Life. Slots remain sharp, side walls highly polished for the life of the plate. There's greatly improved corrosion resistance, too.

3. High, Sustained Yield. Fabricated screen plates assure consistent, uniform quantities of cleaner pulp. This means improved production at reduced operating costs.

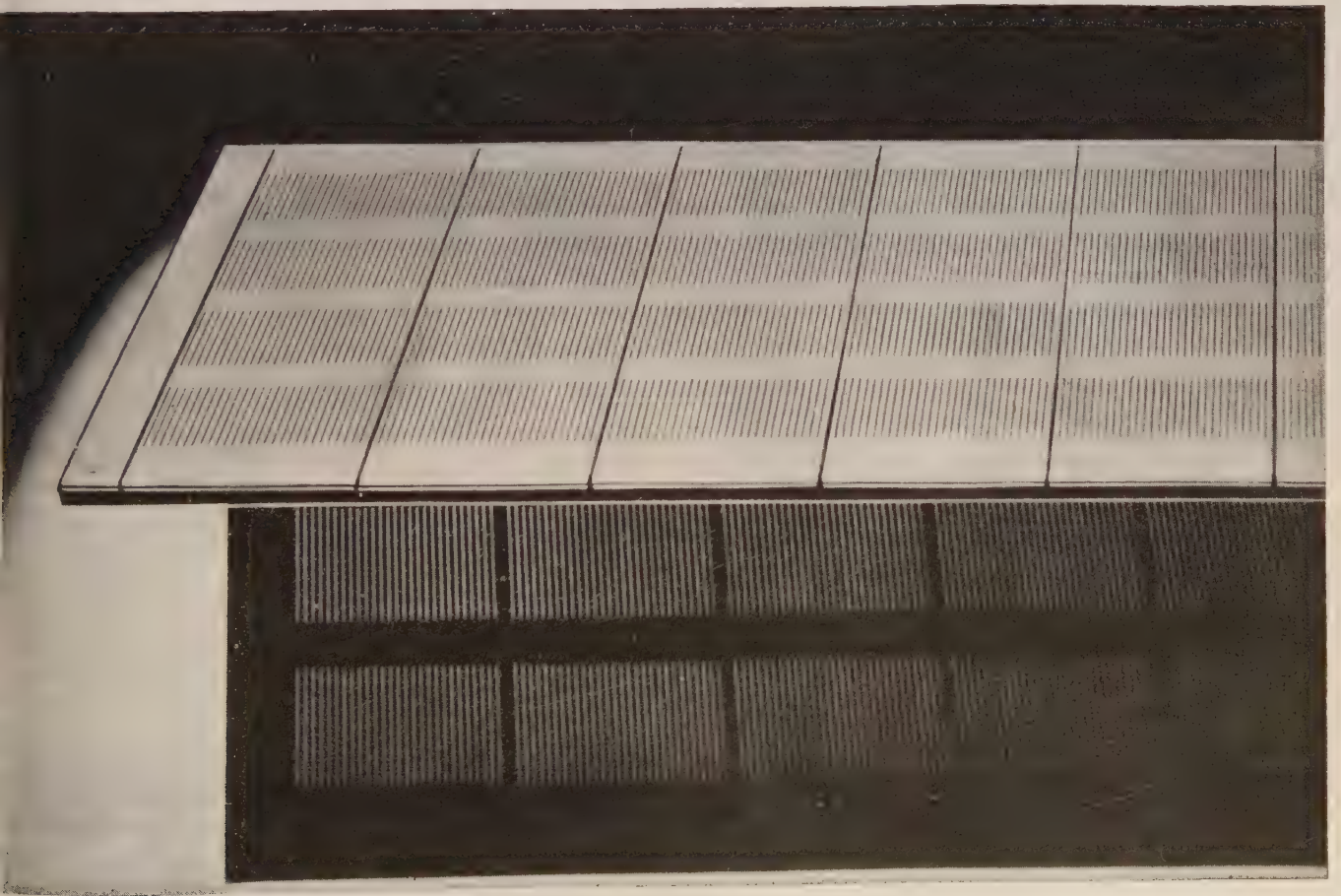
Complete information is yours on request. Or if you like, we'll gladly have an engineer call.



MAGNUS METAL CORPORATION
FITCHBURG, MASSACHUSETTS

Metalworkers for the Paper Trade

CREEN PLATES: BRONZE, CHROME-NICKEL-STEEL, AND INCONEL VALVES: GATE, SWING CHECK, BLOW, GLOBE, ANGLE AND "Y"

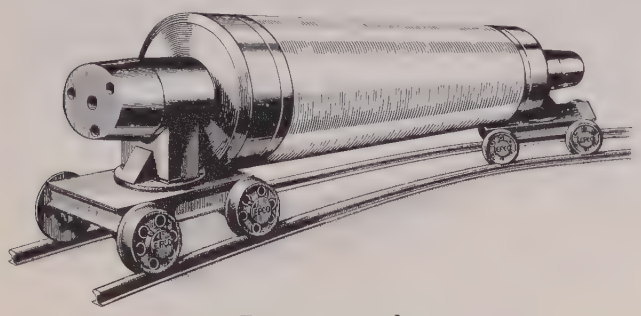


LODDING

President W. C. Lodding has announced changes in the management personnel of the Lodding Engineering Co., Worcester, Mass. The new appointments are: General Manager, David J. Milliken; Sales Manager, Charles S. Connington; Chief Engineer, F. Henry Goyette; Factory Manager, E. R. Ljungquist; Assistant Factory Manager, Leonard L. Krasnow; and Purchasing Agent, Alfred C. Pratt.

EPCO

Engineering Products Co., Inc., 122 S. Michigan Ave., Chicago 3, Ill., has announced a new aid in moving of all calender, embossing, and press rolls. Epco tote trucks are



Epco tote truck

used in tandem so that loads can be moved around corners or along curved trackage. Loads of more than 15 tons can be accommodated.

PLUG

When writing to companies mentioned in this department please advise companies that you saw the reference to their announcement in *Tappi*. In doing this you will help the company addressed, *Tappi*, and yourself.

BALDWIN-HILL

Baldwin-Hill Co., Trenton 2, N. J., has issued a new 20-page catalog "Industrial Insulations."

STOCKHOLDERS

Every one of the 1063 employees of the Phillips, Tex., refinery of the Phillips Petroleum Co. is now a company stockholder. This status was achieved last month when five rival groups within the Frank Phillips Men's Club contested to sign up every company employee. The goal was reached within a few days of the start of the campaign.

U. S. STONEWARE

Frank J. Kiernan has been appointed a Sales Engineer by Howard Farkas, Executive Vice-President of the U. S. Stoneware Co., Akron, Ohio. Mr. Kiernan will be located at the company's office, 60 E. 42nd St., New York, N. Y.

REICHHOLD

As a result of completion of expanded facilities at its Tuscaloosa, Ala., plant Reichhold Chemicals, Inc., will produce 60 million pounds of phenol, annually. Already a potent factor in bonding and laminating plastics, Reichhold is the world's largest manufacturer of synthetic resins and the nation's third largest producer of phenol.

HOOKER

Horace W. Hooker, Jr., has been appointed Assistant to the General Sales Manager of the Hooker Electrochemical Co., Niagara Falls, N. Y.

Charles Y. Cain has been named District Sales Manager for Hooker at its new sales office, 1 N. La Salle St., Chicago, Ill.

The new 12 million dollar caustic soda chlorium plant now under construction at Montague, Mich., will soon be the nearest producing plant of its kind to the midwest market.

In connection with its management development program, Hooker has announced the following temporary appointments: Joseph A. Tardiff and John D. Sweeney will serve as Area Supervisors. These appointments represent the first step in a more formal type of management development program and are a part of an over-all plan for development of reserve management potential to provide for the company's growth and expansion. After serving in these positions for a temporary period and thus broadening their experience, the men will return to their former jobs. Through these means additional young men will be similarly trained.

B & W

The Tubular Products Div. of the Babcock & Wilcox Co., Alliance, Ohio, has issued two new bulletins. Bulletin TB-331A contains tables of maximum allowable working pressures of electric-resistance-welded steel boiler tubes for fire-tube and water-tube boilers. TR-514 discusses how to avoid boiler tube corrosion.

JOHN WALDRON

John Waldron Corp., New Brunswick, N. J., has issued an interesting brochure dealing with its 125th anniversary.

JOHNS-MANVILLE

John B. Johe has been appointed Assistant District Manager of the Johns-Manville Industrial Products Div. at Los Angeles, Calif.

J-M, which operates two asbestos mines in Canada, one of them the world's largest, will develop a third mine at Mashaba, Southern Rhodesia. This step is part of the long-range program of the company to maintain adequate supplies of asbestos ore for many years to come.

LANGSTON

E. B. Seeger has been appointed Assistant Sales Manager of Samuel M. Langston Co., Camden, N. J.

ARIES

Jackson D. Leonard, a Chemical Engineer of Metuchen, N. J., has joined R. S. Aries & Associates, 400 Madison Ave., New York, N. Y., as Senior Associate. Mr. Leonard will specialize on cost reduction programs, reduction of maintenance costs, etc.

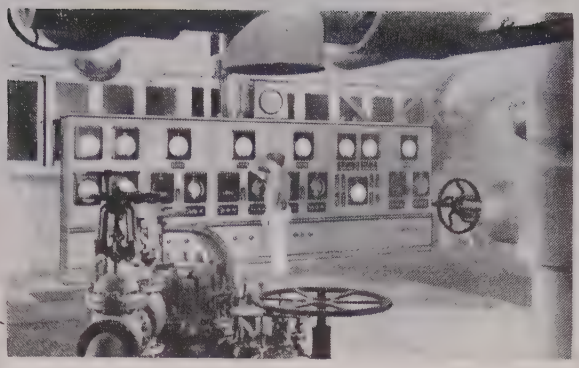
COLUMBIA-SOUTHERN

Louis B. Taylor has been appointed a member of the staff in the Market Research and Development Dept. of Columbia-Southern Chemical Corp., Barberton, Ohio. He will specialize in work related to the pulp and paper industry.

B-C (SHARTLE & DILTS)

The first Beatapulper built by Shartle Bros. under the new Black-Clawson licensing agreement with the Cowles Co. has been installed at the Miamisburg Box Board Div. of Interstate Folding Box Co. at Miamisburg, Ohio. The Beatapulper is a new unit that pulps, defibers, and refines paper stock in one operation. The Miamisburg installation is a 10 SD 8-size unit which has replaced beaters previously used in the top and underliner systems. Quick pulping is effected by a relatively small diameter high-speed rotor which refining of the pulped stock is simultaneously accomplished by means of a hydraulic loaded circular bed plate positioned at the outer periphery of the rotor. A series of special radial blades mounted on the rotor, running in close contact with the radially grooved bed plate, performs the refining function of the machine.

North . . Marathon Paper Mills of Canada, Ltd.
Marathon, Ontario



East . . Brown Company
Berlin, N. H.

West . . Weyerhaeuser Timber Company
Longview, Washington

South . . Mead Corporation
Kingsport, Tenn.

Better pulp production comes automatically with FOXBORO Digester Control

Wherever pulp is made, modern digester rooms like the ones shown above are proof that Foxboro Control is the shortest route to better operation.

With this advanced-design control, you can be sure that every cook will follow the exact schedule you want. Steaming and gas-off will be held to the requirements of the individual cook. Pulp quality and uniformity will be improved, with substantial savings in steam and chemicals.

Foxboro Control Instrumentation is available for *all* types of digesters. For detailed information, discuss your problems with the Foxboro engineer in your area, or write to **The Foxboro Company, 7810 Neponset Ave., Foxboro, Mass., U.S.A.**

FOXBORO
Reg. U. S. Pat. Off.

AUTOMATIC DIGESTER CONTROL

PMAS

The First and Original

LIQUID
PHENYLMERCURIC
ACETATE

Positive Slime Control

TRK

50% water solution of potassium trichlorophenate

Excellent for washups as a slime prevention measure-compatible with scouring agents.

Used sparingly with PMAS during periods of SLIME ACCLIMATIZATION, gives excellent slime control.

Send for your FREE trial samples of these products.

Sole Canadian Distributor: STANDARD CHEMICAL CO.
Toronto 17, Ontario

W. A. Cleary Corp.

New Brunswick, New Jersey | Chicago, Illinois | Belleville, Ont., Canada

Dilts Coating Laboratory

A complete coating laboratory is available for pilot-plant scale trial purposes, and production of commercially equivalent coated products at the Dilts Machine Works, Fulton, N. Y., division of the Black-Clawson Co.

Featured in the coating line is the new Dilts "Contracoater" reverse roll coating machine together with constant tension unwind and wind, oven and after-cooling. The machine will handle webs up to 18 in. in width and will produce commercially equivalent coatings on paper, foil, film, fabric, or other web materials.

The laboratory was opened on April 15, 1952, and the facilities have been used by many paper, fabric, and plastic convertors for a wide range of coating materials.

The coating materials that have accurately and evenly been applied range from low solids lacquers of dry film thickness of 0.00015 in. up to plastisols fused to a thickness of 0.020 in. in one pass. Viscosities have ranged from water emulsions up to rubber cements of 75,000 centipoises. Coatings successfully applied include lacquers, lattices, organisols, plastisols, emulsions, dispersions, rubber cements, and resins with various types of fillers.

A description of the coating laboratory and specifications is as follows:

Maximum speed	300 f.p.m.
Thread speed	25–50 f.p.m.
Minimum cont. speed	12 f.p.m.
Maximum width	18 in.
Minimum width	12 in.
Maximum web tension	10 lb./in. of width
Minimum web tension	$\frac{1}{2}$ lb./in. of width
Maximum roll diameter in unwind	30 in.
Unwind core diameter	3-in. i.d.
Winder core diameter	3-in. i.d.
Winder roll full diameter	24 in.
Capacity of pan on coater	5 gal.

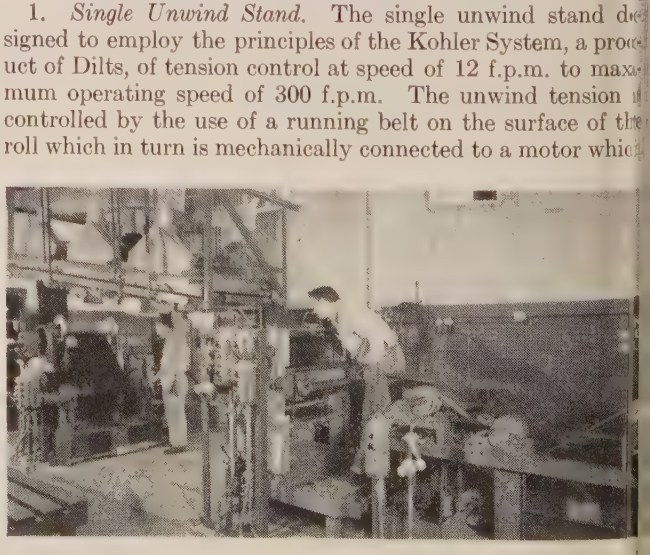
Equipment in the laboratory consists of:

1. Kohler, single belt, constant tension unwind.
2. "Contracoater" for web widths up to 18 in.
3. Two 16-in. diameter cooling rolls.
4. Constant tension center winder with either dancer roll c VSR tension control.
5. Oven section composed of six Radiant superheating panel
6. Complete Reliance VS drive, with individual d.c. moto for each unit, and complete electrical controls.
7. Exhaust system.

The coating laboratory is under the supervision of George Nicholson, Director of Laboratories of Black-Clawson Co, and is operated by a trained technical staff including E. C Paxton, Coating Specialist and Chemical Engineer.

A detailed description of each of the above-listed equipment is as follows:

1. *Single Unwind Stand.* The single unwind stand de signed to employ the principles of the Kohler System, a proc uct of Dilts, of tension control at speed of 12 f.p.m. to max mum operating speed of 300 f.p.m. The unwind tension controlled by the use of a running belt on the surface of th roll which in turn is mechanically connected to a motor whic



Pilot coating machine in the coating laboratory

cts as a driving unit for threading and as a generator for old-back tension control. The tension belt is held in contact with the surface of the roll by a pneumatic cylinder. When ension is set for a given grade and width of paper, it will remain constant during a run and can easily be duplicated in uture runs. The core of the unwinding roll is chucked on a haft which is carried on split bronze bushed, latch type antiriction bearings with provision for sidelay.

Provision has been made for adding another unwind stand, o be mounted above the existing stand, for use when the "Contracoater" is operated as a laminator.

2. *"Contracoater."* This new precision reverse roll coating machine is a development of Dilts Machine Works, for the ourpose of overcoming operational difficulties experienced on existing coating machines.

Exact width of coating can be deposited on any width sheet. Edge doctors predetermine the widths of coating from fountain roll to transfer and metering rolls. Cleaning doctors remove excess coating material from the metering roll so that a clean surface is continually presented for accurate metering.

Perfect alignment is attained by means of accurate bearings, precision wedge-type adjustable stops, and fabricated frames built for ruggedness and rigidity. Adjustable preloaded bearings eliminate bearing shake and vibration.

Chrome-plated rolls are ground to a tolerance of 0.00025-in. diameter to assure accurate metering and application. Rolls position quickly to present mechanical stops by pneumatic loading cylinders. Should rolls be separated for any reason, they automatically return to original setting. Coating thicknesses are set by means of tapered wedges designed for 0.001-in. movement per turn of adjusting screw.

3. *Cooling Section and Dancer Roll.* The cooling section consists of two 16-in. diameter bronze rolls mounted on heavy duty self-aligning antifriction bearings and equipped with rotary unions for circulation of coolant. A fabricated steel frame carries the cold rolls as well as the dancer roll, which consists of a synthane tube roll mounted in antifriction bearings to steel tapes and counterbalancing weights all with as low a moment of inertia as possible.

Movement of the dancer roll in a vertical plane is transformed into an electrical signal by use of an air core reactor so that the winder motor can be slowed down or speeded up accordingly. If more tension is required in the web, it is a simple matter to add to the weight of the dancer roll. It is thus possible to measure exact tensions per inch of web width.

4. *Winder.* The shaft-type winder is equipped with two split, bronze bushed, latch-type bearings. The operating side bearing is equipped with a sidelay mechanism. A simple slide-type keyed coupling connects the winder shaft with a jackshaft which is V-belted to a special winder duty motor. The design of the winder motor is such that either dancer roll signal or automatic electronic speed regulation can be used to control tension in the winding roll.

5. *Oven Section.* The oven section is composed of six Radiant Superheaters manufactured by Industrial Radiant Heat Corp. These are mounted three above the web and three below, giving about 9 linear feet of heating surface. The two sections, of three heaters each, are hung on chains and opened and closed by means of an air cylinder connected to the top section. The air cylinder is electrically controlled by a solenoid valve, so that the sections automatically open when the web is stopped. Blowers mounted on the back of each of the heaters produce a continuous flow of filtered air through the heating unit across the web.

Temperatures up to 700°F. can be obtained and controlled by means of six Brown Exactline Pyrometers, which operate from thermocouples mounted on the surface of each of the heaters.

An exhaust system of 1000 c.f.m. capacity draws solvents from the web through ducts on each side of the heaters between the top and bottom sections.

Permutit-Treated Water

IS KIND TO PAPER!

Color and suspended matter in water cause objectionable stains and off-shades . . . dull both white and colored products. Iron and manganese stain all products—even unbleached—promote the growth of bacteria which let go in batches . . . clogging lines, nozzles. Calcium hardness forms scale in bleaching tanks that breaks loose in discolored chunks . . . contaminating pulp.

The Permutit Precipitator employs a minimum of space, time and chemicals to remove these costly impurities . . . delivers a high quality effluent that eases the load on filters. Write for full information: THE PERMUTIT COMPANY, Dept. TAP-10. 330 WEST 42nd STREET, NEW YORK 36. (In Canada —Permutit Co. of Canada, Ltd., 6975 Jeanne Mance Street, Montreal.)

PERMUTIT CONTROLLED PROCESS WATER MEANS:

- Clean high quality paper products.
- Higher production—lower production costs.
- More sales . . . bigger profits.

PERMUTIT®

WATER CONDITIONING HEADQUARTERS FOR 40 YEARS

6. *Reliance Drive.* The all-electric d.c. sectional drive receives its power from Reliance VS control units completely engineered to power all motors on the coating line.

All pushbuttons and rheostats, with the ammeters and speed indicators calibrated in f.p.m., are mounted on a large panel. The operator controls the speed of each unit, plus speed of all units together, tension in the web, and also the heat in each section of the oven from the control panel. All units may be accelerated or decelerated at a preset, constant, and uniform rate and speed adjustment is stepless throughout the entire operating speed range. Dynamic braking is available for emergency stops in addition to normal smooth controlled tension stops.

The unwind braking generator is used as a motor for threading and is then switched to operate as a generator for tension control when a run is started. Tension in the web is adjusted by means of rheostats and is indicated on ammeters for each section motor.

The "Contracoater" is driven by two d.c. gear motors one driving the backing roll and the other driving the three bottom rolls. Speed of the backing roll is adjusted by means of a rheostat and is read in f.p.m. on the speed indicator. Speed of the bottom three rolls is adjusted by rheostat and red on another speed indicator calibrated to show the speed of the applicator roll in f.p.m. Whenever the backing roll and web are raised from the applicator roll the bottom three rolls of the "Contracoater" automatically go into a slow agitate speed to prevent coatings from setting up in the pan. A rheostat can be used to adjust the agitate speed of the bottom rolls to assist in determining roll adjustments for coating thicknesses.

All motors and controls, including rheostats, ammeters, tachometers, pushbuttons, and wiring, are *completely* explosion-proof.

7. *Exhaust System.* Two separate exhaust systems are maintained. The exhaust system for the oven is composed of two 500-c.f.m. blowers, one for each side of the heaters. The ducts on each side of all three banks of heaters are piped into headers which lead directly to two 500-c.f.m. blowers mounted on the roof, control side and drive side are thus exhausted separately. Flexible hose connections allow the heaters to be raised and lowered without affecting the exhaust. Dampers in the ducts on each heater control the flow of air through the system.

The other exhaust system comprises one 1000-c.f.m. explosion-proof blower with an exhaust duct along the wall behind the motors, about 6 in. from the floor. A duct runs from the pan on the coater into the wall duct to evacuate excess solvent vapors before they can spread into the room. Extra ducts can also be run from each end of the oven section into the main duct, if required.

Inquiries regarding the use and scheduling of the Dilts laboratory should be addressed to R. J. Jacobs, Manager of Sales & Engineering, Dilts Machine Works, Fulton, N. Y.

Westinghouse

Westinghouse believes that, to be a good citizen in our industrial society, it should do more than make and sell high quality goods and services. For one thing, it gives active and substantial aid in the field of scientific, engineering, and business education.

The educational activities of Westinghouse are both numerous and varied. Some are of benefit to students directly. Others are designed to assist teachers. And some deal with company employee training and educational programs. These programs are administered by the Westinghouse Company and by the Westinghouse Education Foundation, established for that purpose in 1944. The Foundation has separate corporate entity and its own trustees and management. Its funds come solely from the parent company. In all, the company and the Foundation maintain 156 scholarships, 13 fellowships, and 4 professorships.

Production Men Like Tracerlab BETA GAUGES Because...
Tracerlab Beta Gauge installed at The Gilbert Paper Company, Menasha, Wis.
Every production man is interested in cutting costs and improving product quality. If you can do both at the same time you've got an unbeatable combination to fight today's competitive battle. Manufacturers who have installed Tracerlab Beta Gauges for sheet process control are reaping both these benefits. Here's what two out of many say:
$ "Ability of Tracerlab Beta Gauges to hold product thickness variation to ±.002" instead of ±.004", as formerly, enables operators to work more closely to minimum specifications, thus making possible savings of over $150,000 yearly." (Two Tracerlab Beta Gauges in use, two on order.)
$ "Use of Tracerlab Beta Gauges has increased our product acceptance from 89% to 97%. (Four Tracerlab Beta Gauges in use, another on order.)
MULTIPLE gauge installations mean only one thing: Tracerlab gauges are delivering the goods, are paying their way through cost savings and quality improvement.
ASK for free booklet, BG-1T "Tracerlab Beta Gauges"
Tracerlab
130 HIGH ST., BOSTON, MASS.
Berkeley, Cal.
New York, N. Y.
Washington, D. C.
Chicago, Ill.

The Westinghouse Science Talent Search is a means of ncouraging, at the high-school level and on a national scale, tudy of the sciences. Each year, from some 15,000 appli- ants, 300 top students are selected to compete for 40 college cholarships and other rewards. Not only does this search, upported by the Foundation, provide direct aid to 40 of the ost promising youth in the field of science but it also has side ffects. Because of the national attention the competition rings to all the participants, the 260 honorable mention inners almost always receive other scholarship offers and ncouragement to continue their education in scientific fields. ttention also is focused generally on the country's great eed for technically trained men and women for tomorrow.

Through the *4-H Farm and Home Electric Awards Program*, Vestinghouse cooperates with the Extension Services of the nited States Dept. of Agriculture and the individual states. he Program is designed to help farm youth learn more about he productive uses of electricity on the farm and in the home. ounty, state, and national awards, as well as special awards or Negro 4-H'ers and for participants in Hawaii, Alaska, and he Philippines, are underwritten by the Westinghouse Edu- ational Foundation. Westinghouse has been sponsoring his program since 1936, when only about one million farms ere electrified. At that time only 2000 boys and girls in 4- H Club work undertook projects involving electricity. Last ear, 78,000 participated.

Assistance is given by the Educational Foundation to the *uture Farmers of America Foundation*. This group is com- osed of about 275,000 boys in rural high schools who are tudying vocational agriculture and who intend to follow arming as a career.

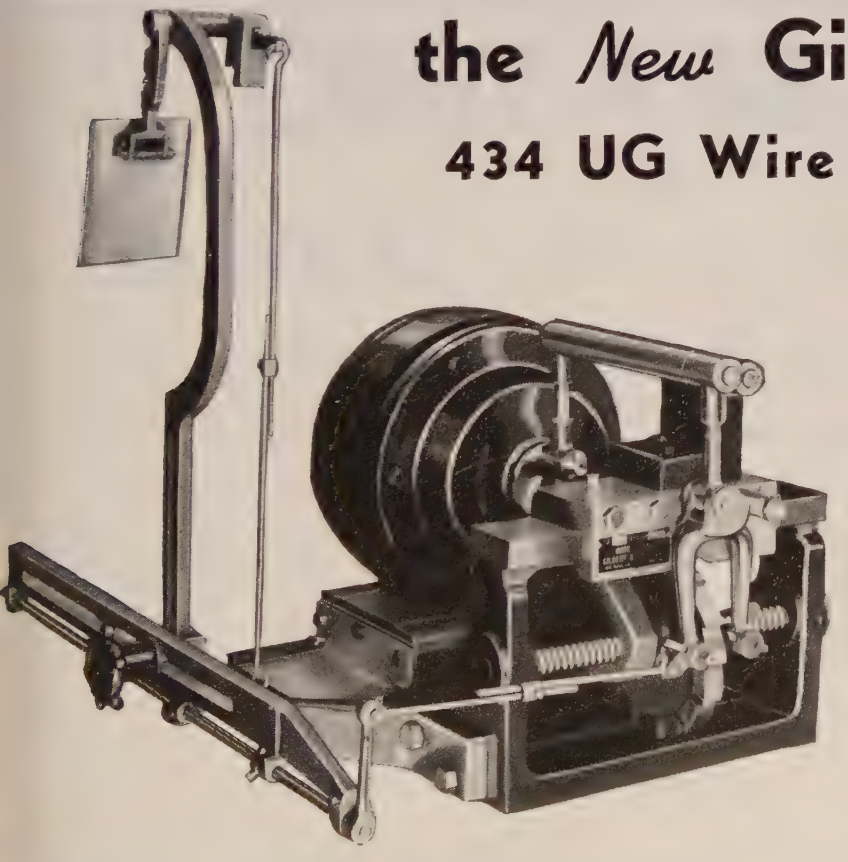
Direct aid in the form of *scholarships* is given many engi- neering college undergraduates. The Foundation currently rovides scholarships for 23 engineering students. These chievement Scholarships are established at universities to be warded to Juniors in engineering who have shown excep- tional promise and who deserve reward in their Senior year. This reward is a scholarship that first, recognizes their achieve- ment and second, encourages them to continue their superior work.

Ever since World War I, four *War Memorial Scholarships* are granted by the company to junior employes or to sons of Westinghouse employees on a stiff competitive basis. These extend over the usual four years and are usable by the winners in any accredited engineering college.

The George Westinghouse Scholarship Program. Each year the Carnegie Institute of Technology conducts a nationwide contest for 10 scholarships underwritten by the Foundation. Each is a four-year scholarship and currently covers tuition plus a modest allowance for certain necessary expenses. The competition has become so well established among leading high schools in the country that the number of contestants runs as high as 1500 per year.

A new and novel venture in technical training in connection with Westinghouse manufacturing operations in the Balti- more area is being watched with interest by educators. As a result of competitive examinations 30 high-school graduates who are unable without assistance to continue their under- graduate education are given positions at regular wages in the engineering and manufacturing departments of the company's plants in the area. By arrangement with local universities these young men take selected courses in science and engi- neering. At the outset Westinghouse pays one half the tuition for each course successfully completed and if the worker- student satisfactorily completes the entire course of study he receives a certificate to that effect and is reimbursed for the second half of his tuition.

Education must not stop with the granting of a degree in science or engineering. Graduate work is becoming more and more important in our complex industrial society. To this end the Foundation grants fellowships to 27 men and women of outstanding promise for study beyond the bachelor's degree.



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These fellowships encourage work not only in engineering but also in industrial relations and business administration. While in a few special cases the fellowships carry a high stipend, most are between $1200 and $1500 per year, plus an allowance to the school, in most instances.

In an integrated education-assistance program, the teachers are as important as the students. As evidence of the realization that the groundwork for future scientists is laid in the high schools, science refresher courses are provided by the Foundation for up to 100 *high-school science teachers* each Summer through fellowships. These are divided between two programs of six weeks each. One is conducted at Massachusetts Institute of Technology and the other at Carnegie Institute of Technology.

The Foundation maintains four *professorships* in different fields at different institutions. It also provides $1000 given as an award each year by the American Society for Engineering Education to the young teacher of engineering whose ability, teaching methods, and guidance of students has distinguished him above his contemporaries.

Professors of science or engineering have a very real problem in keeping abreast of developments in today's fast-moving technology. Of major assistance with this is the *Summer Experience Program for Professors.* Each Summer some two dozen professors from schools of engineering, business administration, and liberal arts spend several weeks on work assignments in their field in various Westinghouse plants, which enables the professors to establish contact with experts and to observe current practices in their field of interest. The period ends with a week's seminar during which they discuss management problems with key people in Westinghouse administration and technical departments.

The oldest, most major, and best known of all the Westinghouse educational programs is the *Graduate Student Training Course.* Established about 50 years ago this course provides nine months to a year's specialized instruction in engineering, manufacturing, and sales to the several hundred science, engineering, and business administrator graduates hired each year. Some 17,000 engineers, comprising the main source of new technical talent for the company's operations, have received this postgraduate training.

Education is a continuing thing. For this reason Westinghouse employees are encouraged to continue their training beyond college. Special arrangements are made with 11 universities in Westinghouse plant cities for employees to take *graduate courses* of their choice—technical or otherwise, in the late afternoon and evening. A substantial portion of the tuition fees are paid by the company. In 25 years, 6000 employees have taken courses for credit, of which many have led to graduate degrees, totaling 248 M.S. and 17 Ph.D.'s.

This growing partnership of industry and education has many benefits—to industry, to educators, to students, to the future of science and engineering, and to America. Some of the programs—such as the Science Talent Search—are, from the point of view of the sponsor, purely an investment in the future. Westinghouse realizes that the quality and quantity of technically trained people five and ten years from now depends on encouragement given the youngsters of today. Other aspects of the Westinghouse educational interests are motivated by a realization that whatever helps in the field of advance education eventually helps the companies who use technology in producing their goods and services. Some, of course, like the student training program, are of direct, immediate benefit. They are an absolute necessity in placing the high-grade talent in the right quantity and kinds required if an engineering business is to grow and progress.

Westinghouse realizes that raising all levels of scientific and engineering training increases the technical abilities of the nation. This in turn, benefits everyone concerned with technology—i.e., everyone—benefits.

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TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Fourdrinier Papermaking Committee

Tissue Subcommittee

The subject of the round-table discussion of the Tissue Subcommittee, Fourdrinier Papermaking Committee was "Fourdrinier Table Arrangement and Tissue Machine Operation."

This discussion was based on a questionnaire survey. The responses to this inquiry are summarized as follows:

Table Rolls

(a) Fifty per cent of the producers of tissue use solid table rolls with an average of six rolls per machine.

(b) Thirty per cent of the manufacturers use dandy rolls exclusively with an average of four rolls per machine.

(c) Thirteen per cent of the machines use both solid table rolls and dandy rolls, averaging one dandy and three solid rolls per machine.

Deflectors

All producers use water deflectors with an average of five per machine. There appeared to be no consistent pattern as to style or location.

Suction Boxes

(a) Most operators use two to three suction boxes per machine, the maximum being four.

(b) There was an overwhelming preference (90%) for end grain maple covers. One producer stated that he used leather and the balance used composition covers.

(c) Eighty per cent of the boxes utilized the herringbone or slotted type cover.

Headbox Consistencies

Consistencies varied between 0.2 and 0.7% with an average of 0.3%. The average flow box nozzle delivery was 21 g.p.m. per inch of lip.

Wires

(a) Wire lengths varied from 40 to 65 ft., with an average of 45 ft.

(b) 75/56 and 75/60 mesh wires were the choice of 80% of the operators; a few run 80/60 mesh wires.

(c) Wire retention averaged 61%.

Wire Showers

(a) The number of showers per wire varied from one to five, with an average of three per machine.

(b) Sixty per cent of the showers were operated with fresh water.

(c) Average shower pressure was 50 lb.

Weights

Basis weights varied from 9.5 lb. (creped) to 30-lb. M.G. sheets.

Speeds

Machine speeds varied from 400 to 1760 f.p.m., with 50% of the machines running over 1200 f.p.m.

The following summarizes the group discussion:

1. It was the consensus that the greatest sheet disruption is caused by throw-up from the table rolls (solid and dandy). There was an affirmation of the fact that when dandy rolls are used in conjunction with solid rolls, the dandy should be positioned nearest to the inlet.

There appears to be a definite trend toward the removal of rolls from under the wire. Some machines are running without rolls under the first 5 or 6 ft. of wire and, in one instance, all table rolls were removed and the wire was supported solely by maple deflectors.

Some operators are of the opinion that the transition from solid to dandy type rolls can be more easily accomplished with the use of the finned type table rolls. Reports indicated that solid rolls driven at speeds in excess of the wire speeds apparently had little or no effect on sheet formation or characteristics.

2. Both the questionnaire and the discussion revealed that there is a great deal of variation in the styles and construction of water deflectors presently being used. The majority of the operators are using the flat type deflector with both edges tapering under to form a double knife edge. The width of deflectors varied from $^3/_8$ to 2 in. across the top surface. Especially interesting was a report concerning a deflector made of 1-in. stock, with the top having an egglike contour. When this deflector was placed slightly below the wire, drainage was improved 13% over that of a flat type deflector running against the wire. Aside from better water removal, it was felt that there was less chance of interruption and that longer wire life would also result. It could well be that a research project in this area would be of benefit to the producers of tissue.

Several operators have experienced trouble with composition blades buckling. Hard rubber, stainless steel, or maple seemed to be the preference of the majority.

3. A discussion of wire retentions developed the opinion that stone-beaten stocks resulted in a 75% retention level as compared to a 50 to 60% retention for jordaned pulps. There were expressions that a study of pulp preparation and its relationship to drainage and sheet characteristics might be of considerable value.

4. The discussion of wire characteristics, wire life, and cleaning methods resulted in some interesting observations:

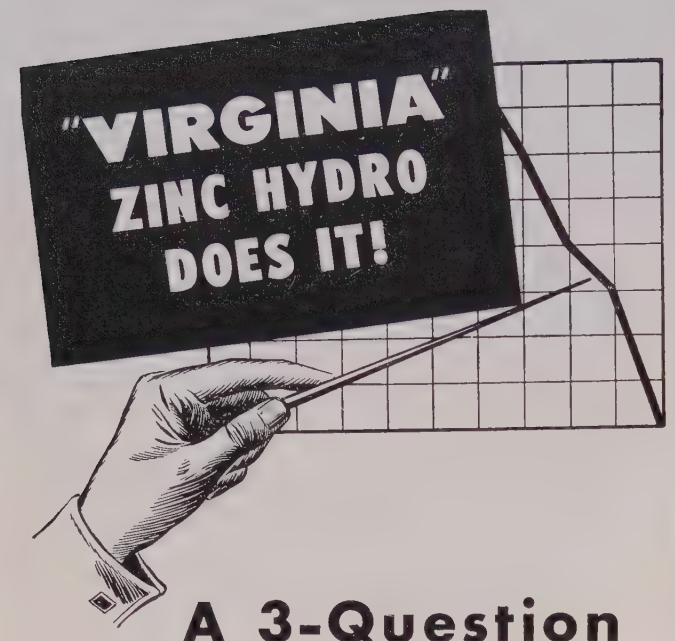
(a) There is some evidence that there is a critical speed range (depending on table roll diameter) somewhere in the neighborhood of 1400 to 1450 f.p.m. where wire life actually increases. It was felt that this was due to centrifugal force forming a film of water on the surface of the table rolls and reducing frictional wear on the wire.

(b) It was the definite opinion of the operating group that long crimped wires tended to fill much more readily than standard weave. The committee intends to relate this information to the wire manufacturers, feeling that they might well effect some research work in this area. In the scope of operational control, it was thought that a reduction in the number of suction boxes and decreased vacuum would alleviate filling. Some fibers such as white fir are apparently more susceptible to filling than the fibers from other woods. It is also felt that pH may influence the degree and rate of fill.

(c) Various methods were offered for cleaning filled wires:

(1) Filling was prevented from the use of a hydrosilica pump, equipped with a No. 7 Rex spray nozzle and operated at 1000 p.s.i. The nozzle was positioned 4 to 5 in. from the wire and moved across the machine once every 8 hr. This equipment can also be utilized to clean dandy type table rolls.

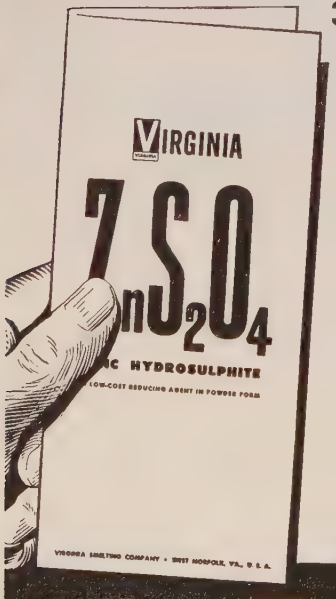
(2) It was reported that in Germany hot hydrochloric



A 3-Question Quiz on Economy

"Virginia" Zinc Hydro has been used as a groundwood bleach long enough for its brightening properties to be proved. Groundwood mills contemplating installation of a bleaching process should consider these questions:

1. What increase in brightness can be expected?
2. What will be the ton cost per unit of brightness to bleach with Zinc Hydro?
3. Is a capital investment for auxiliary equipment required in the Zinc Hydro process?



When you have the answers to these three questions, we predict an acute interest in "Virginia" Zinc Hydrosulphite. May we send you the answers with a product sample for testing purposes?

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acid is sprayed on the wire just before the sheet is put over the machine. The application is usually not made during the first two or three weeks of the wire's life, but is then employed every week, with excellent wire life being secured. If pickup trouble is encountered after the acid treatment, an application of sodium hydroxide should remedy the trouble.

5. The subject of deckle devices proved to be a controversial one. Some operators believe that it is desirable to run the full trim sheet over the machine. The reason for so doing was to increase felt life and keep the edges of the drier cooled.

A vacuum deckle was described which employed slotted nozzles, positioned approximately $^1/_2$ in. above the wire in the suction box area and sufficiently wide to remove from 1 to 2 in. of the sheet edge. The salvage is passed to a vacuum separator and returned to the stock system.

The majority of machines seemed to be equipped with water deckles washing the edge of the wire. The No. 7 Rex nozzle was a popular preference of those employing this type of deckle.

6. There was a brief discussion regarding the pitch of the wire (uphill, downhill, or level). The uphill wire was attributed with achieving greater cross-direction tensile in at least one case. It seemed to be the majority opinion that the same end can be accomplished by slice and headbox adjustment. Operators in the creped tissue, facial, and sanitary field expressed a preference for the short wire (30 to 35 ft.).

7. Although the discussion was primarily confined to wet end conditions, there was an interesting report concerning the coating of a cast-iron Yankee drier with stainless steel. The steel was sprayed on and the drier ground. It has been in operation for a considerable period and used in conjunction with a bronze creping doctor and is giving excellent results. This information could prove exceedingly useful where an operation is handicapped by a badly scarred or pitted drier and management is faced with the alternative of complete replacement.

The group was requested to give thought to suggestions for discussion at the next session. They were also asked to suggest areas where research might be of assistance in helping operators with some of their production problems.

L. P. THOMPSON, *Chairman*
Tissue Subcommittee
Personal Products Corp.
Milltown, N. J.

LETTERS TO THE EDITOR

Drying Rates of Pulps

To the Editor, *Tappi:*

We received, a while ago, some data sheets, which we are reading with much interest, and for which we thank you. In order to make it easy for our technical staff to read these documents, we have decided to transform them into the metric system.

Having examined the sheets concerning the evaporation drying rate of pulps and papers we notice that the steam temperature is quite higher than the one corresponding to the steam pressure. We suppose then that the drier parts are working with overheated steam?

Have the results given by the graphs been obtained on ordinary drier parts with or without modern installations for the evacuation of the vapors surrounding the driers?

ANDRE BEYLIER, *Engineer*
Grenoble, France

To the Editor, *Tappi:*

I suggest you reply to the letter dated July 10 from A. Beylier telling him that the steam temperatures shown on the drying rate data sheets are the correct saturation steam temperatures corresponding to the steam pressures as given. I suspect that the difficulty has arisen due to our using gage steam pressures whereas he is thinking of absolute pressures. As you know, we always speak of steam pressures as gage pressures unless stating that it is expressed as the absolute pressure.

The data shown on these graphs were obtained from a large number of machines selected without regard to whether or not they had supplementary air systems. We endeavored to get data on all the machines making the stated grade of paper, but the data are shown only for those who reply to our questionnaires. Most of these did have air systems, because most of the machines in this country are so equipped.

A. E. Montgomery, *Vice-President*
J. O. Ross Engineering Co.
Chicago, Ill.

A Bouquet

To the Editor. *Tappi:*

Congratulations! I was delighted to read in the July issue of *Industrial Marketing* that your magazine has been awarded a Certificate for outstanding editorial achievement.

As Editor of *Tappi* you are doing a magnificent job. Your publication is a favorite among our staff members.

With kindest personal regards,

J. E. Tobey, *President*
Appalachian Coals, Inc.
Cincinnati, Ohio

Liner Board Strength Relationships

To the Editor. *Tappi:*

We would like some information in regard to strength characteristics of test liner boards.

1. Is there a relationship between mullen strength and tear resistance?
2. Is there a relationship between mullen strength and compression strength?
3. Is there a relationship between mullen strength and tensile strength?
4. Is there a relationship between mullen strength and stiffness?

These questions arise from customer requirements for high mullen strength in cartons and disappointment when cartons are not completely satisfactory in all strength requirements. The disappointment is usually expressed in the words "The board is not strong enough."

It appears to me that mullen strength could be held to a reasonable value with additional emphasis put on tear and tensile strength particularly for bottle and can carrier cartons. I have been told that when the maximum mullen strength is developed from a given furnish, the fibers are shortened and bender is sacrificed. If this is true I should think it would be better to find a reasonable mullen, retaining good bending qualities and develop added strength in other characteristics.

I would appreciate any information you may have on this subject.

Ed. Note: For obvious reasons the identity of the inquirer and the respondents are omitted. The inquiry and the responses are published for their information value.

Response No. 1

In the manufacture of paperboard mullen strength happens to be the most commonly used measurement of strength because the railroads wrote it into their specifications years ago when it was about the only strength test known.

Where the Finish Enters the Sale

Top grade paper calls for top grade finishes. Whatever the end use of the paper, quality calendering is a *must* — for satisfied customers, better profits.

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Make this simple test. Put a single Butterworth Roll in the stack. First, examine the smooth, uniform surface it gives. Then, check the time. Find out how many extra hours of production you get without having to turn down or refill.

Butterworth Rolls are made to your specifications. Tests are made in series before a roll is pronounced satisfactory . . . before it is delivered to you. Butterworth Calender Rolls are furnished new or refilled for every calendering need.

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If your furnish contains any ingredients that must be finely dispersed for quality products, Beatex will do a better job than any other available product. Many mills are using more low-priced furnish because of the job Beatex does.

2 Improved Formation and Freeness

Beatex gives you more uniformly defibered and hydrated stock, and a better web. Water drains off faster and easier. There is better interlacing of fibers and better retention of fillers and short fibers.

3 Reduced Beating Time

Power and steam are saved at the beater as well as at the jordan.

4 More Efficient Press Rolls... Lower Drying Costs

Paper is materially dryer when it reaches the press rolls. Water content is lower all along the line, so that less heat is needed for drying.

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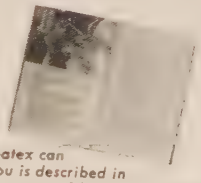
There is less slime build-up when Beatex is used, due to its effect in minimizing the bond between slime and the metals of the system.

6 Improved Absorbency

Where desirable, absorbency can be greatly increased by the use of Beatex in suitable proportion.



What Beatex can do for you is described in detail on pages 15 to 18 of the Magnus Paper Mill Handbook. Look it up... or if you haven't a copy handy, write for one today.

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CLEANERS • EQUIPMENT • METHODS

Generally speaking, a board with a high mullen will also have high tear and high tensile strength. However, it is true that with a particular furnish the tear and tensile are both reduced when the maximum mullen is developed. Up to a point mullen strength increase will mean increase in compression strength and stiffness. However, it is possible to make a very stiff high compression strength board by cutting the fibers to such an extent that the mullen will be lost.

With the knowledge available today it probably would be possible to write specifications for corrugated boxes used in rail shipments without the use of the mullen tester and to have better specifications than we presently have. However, this has not been done and it is questionable whether it will be done, therefore, we must first meet the mullen specifications of the railroad classification committee and then attempt to build into our boxes the other characteristics that are desirable for particular usage. It is true that where you are thinking of can cases, tensile strength across the score line is especially important. However, a furnish that is adequate to furnish this extra tensile strength will usually have plenty of strength to meet the mullen test required by the railroads. The same is true of bender where the furnish is adequate to give the necessary bender the mullen requirement will usually be there. It, of course, is foolish to keep the strength reduced to the point where adequate treatment to produce the required mullen results in poor bender.

I think that the writer of this letter might be interested in a pamphlet entitled "The Manufacture of Fibre Shipping Containers," by A. W. Werner, which was originally published serially by Fibre Containers and has since been published by the Board Products Publishing Company, 228 North LaSalle Street, Chicago 1, Illinois, in booklet form. This gives quite a little information on testing methods in relation to corrugated and solid fibre.

Response No. 2

This inquiry was primarily on the relationship between Mullen and tear, compression, tensile and stiffness. It is my opinion that there is no definite relationship between these tests. For example, on pulp testing you will find that progressive beating develops in the following set of curves:

The Mullen will increase with the degree of beating, and the tear will originally increase and then decrease; and while there is a corresponding relationship between these two in that one goes up and one goes down, there is no way of guessing what the tear might be when you have a fixed Mullen.

On compression strength and Mullen, virtually the same applies. The compression strength of linerboard or corrugated board is due to fabrication as well as the original material from which the cartons were made, and it is possible to have the same compression strength with board of 100 lb. Mullen or 200 lb. board, although as the Mullen increases there is a tendency toward increase of compression strength.

The relationship between tensile and Mullen is a little closer but still cannot be considered a definite and fixed relationship. Generally, if the tensile is low, the Mullen will probably be low, and if the tensile is high, the Mullen may be either high or low, depending on what the stretch and flexibility of the sheet were.

The relationship between Mullen and stiffness follows much along the same line. It is possible that you might have a stiff but brittle sheet which will have a low Mullen—in contrast to a stiff but strong sheet which will have a high Mullen.

It is generally agreed that the Mullen test is not an answer to a universal test for equipment, but we all stick with the Mullen, because we do not have anything to replace it at this time.

Response No. 3

1. Is there a relationship between mullen strength and tear resistance?

In the normal course of events, all other variables being equal as regards fiber furnish, type of board, i.e., cylinder or fourdrinier, etc., it is to be anticipated that as mullen strength went up or down, tear resistance would probably go up or down also. It should not be assumed by this statement, however, that there is necessarily a direct correlation between the two tests, for this is not true. Where the degree of pulp preparation varies between different pieces of board and where you are comparing cylinder against fourdrinier formation, the results may show no relationship whatsoever. All in all, I would say that any broad attempt to correlate these two values would not be too successful.

2. Is there a relationship between mullen strength and compression strength?

Again, the comments relating to the first question are quite applicable here. Naturally, as you use heavier grades of material which develop higher mullen strength, if other things remain equal, you could anticipate improvement in compression values. Here again, when the other variables such as type of formation, type of fiber, and other factors enter the picture, the relationship between mullen and compression ceases to exist.

3. Is there a relationship between mullen strength and tensile strength?

There is probably closer relationship between these two values than any of the others mentioned. It has been shown that the bursting strength of paper is functionally related to stretch and tensile strength. The relationship is confused in the case of paperboard and corrugated box board because of bending and shear failure at the edge of the orifice and crushing of the corrugating medium prior to failure of the liners when corrugated board is tested.

4. Is there a relationship between mullen strength and stiffness?

I know of no specific investigation of the relationship between these two characteristics, but offhand it would be my guess that there would be very little.

Your correspondent is bumping into the typical situation that often develops when the mullen test is used as the only basis of evaluating merit. Since its results do not correlate well with many requirements in service, it is natural that arguments and disappointments develop.

Drying Rates

To the Editor, *Tappi:*

With reference to the TAPPI Data Sheets on Drying Rates, I should like to inquire about one item that I do not understand.

All the curves start from steam pressure equal to zero, or even below zero. Some plotted points are also in the vicinity of steam pressure equal to zero. Would you be kind enough to explain this phenomenon.

FR. PFULG, *Engineer*
Bur. Tech. L'Industrie Papier
Cologny, Geneva, Switzerland

To the Editor, *Tappi:*

Please advise Mr. Pfulg that we do have, in this country, on certain grades of paper a fair number of machines operating with an average steam pressure in the driers on zero p.s.i. or even lower.

In most cases, I believe it will be found that the pressure is graduated with the wet-end driers operating often at considerable vacuum and the dry-end driers at perhaps 2 or 3 pounds steam pressure. After all, if there is sufficient drying surface there is no reason why paper cannot be well dried with zero p.s.i. in the driers.

I believe it is understood by Mr. Pfulg that the curves were

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Reaction of ¾" Auto-Flex in 48" dia. dryer. Very low leverage.

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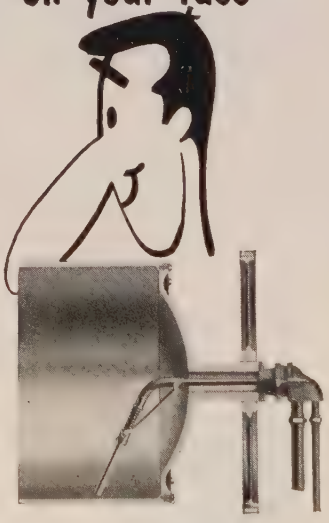

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End of pipe takes correct position and cannot possibly change its position. That means proper water and air removal. Reduced leverage, compared to other syphon pipes, permits the "pipe" to clear and stay clear of the journal. And that means freedom from wear, hence far longer life.

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DAYTON, OHIO

drawn to correspond with the data and not from any preconceived idea of how they should run except in the cases where the data is inadequate to determine the slope of the curves, in which case they are drawn to correspond with the slope which has been found in the cases of other grades of paper where there was adequate data.

A. E. Montgomery, *Vice-President*
J. O. Ross Engineering Co.
Chicago, Ill.

RECENT BOOKS

Solving Everyday Paper Problems. By Chas. V. Morris, Reinhold-Gould, Inc. 93 Worth St., New York, N. Y., Walden Sons & Mott, Inc., 1952. Paper-bound, 6 × 9, 84 pages.

This interesting and very useful book has been prepared primarily for paper merchant's sales training programs and is available only as a premium for a subscription to *Paper and Paper Products*, published by Walden Sons & Mott ($4.00 per year) (present subscribers $2.00).

The contents cover the following chapters: How to Write Orders, How to Order Paper in Rolls, Bulk Factor, Equivalent Weight Factor, Strength and Durability, Color and Finish, Unusual Papers, Paper Testing Methods, Grading Cover Stock.

Technology of Coated and Processed Papers. Edited by Robert H. Mosher, formerly of the Miami Valley Coated Paper Co. New York, Remsen Press, 1952. Cloth, $5^1/_2 \times 8^1/_4$, 733 pages, 170 illustrations, 100 tables. $15.

As a companion volume to "Specialty Papers," Mr. Mosher has brought together in one volume a vast amount of technical and operating information dealing with coated and processed papers. Associated with him in the preparation of this work are William A. Abramowitz, American Resinous Chemicals Corp.; Maurice C. Beren, Pyrotex Leather Co.; Frank C. Campins, Polymer Industries, Inc.; Philip H. Dewey, R-B-H Dispersions; Frank W. Egan; Bert C. Miller, Ralph J. Nazarro, Westfield River Paper Co.; J. C. Perrone, Watson-Standard Co.; and Ashworth N. Stull, American Polymer Co.

The purpose of the book is to cover the general types of operations involved in the converting of paper, the equipment used in converting operations, and the method of evaluating the products from the angle of the technical man, the engineer, and the chemist.

Among the subjects covered are: Theory of High Polymers, Rheology of Coatings, Water-Soluble Coatings, Solvent Coatings, Hot-Melt Coatings, Paper Converting Machinery, Printing Inks and Processes, Adhesives and Laminating Procedures, Paper Saturation; and Testing of Raw Stock, Raw Materials, and Specialty Papers.

There was a real need for the two books edited by Mr. Mosher. He and his associates have done much to fill this need.

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P207-52. Sales Engineers. Bingham Pump Co. has openings in their sales offices for graduate engineers familiar with the pulp and paper industry. A minimum experience of 5 years of pulp mill service or with equipment firms who specialize in pulp and paper machinery. Give complete background of education, experience, and salary requirement, along with recent photograph.

P226-52. Paper Coating Chemist for laboratory of upper midwest manufacturer of bleached and unbleached groundwood, sulphite, kraft pulp, printing, and converting papers. Prefer chemist or chemical engineering graduate with 2 to 4 years' applied research experience in paper coating field. Reply giving personal history, experience, and salary expected.

P227-52. Research man with paint or coating formulation experience for laboratory of upper midwest insulating board manufacturer. Prefer chemistry or chemical engineering graduate with 1 to 2 years' experience in paint or insulating board industry. Reply giving personal history, experience, and salary experience.

P241-52. Mill Manager with experience in the paper coating field. Operations include coating, friction calendering, embossing, laminating, and printing.

P242-52. Recent papermaking or chemical engineering graduate with some technical experience in paper or paperboard desirable. Man selected will be responsible for product and process development work as a member of the technical staff in a progressive, integrated midwestern board mill. Excellent advancement opportunities exist. Give complete background of education and experience along with salary requirements.

P243-52. Association Staff Engineer. 30 to 40 years. Duties include technical correspondence covering all aspects of pulp and paper technology; coordination and promotion of committee activities, preparation and editing of special reports and monographs, standard testing methods, technical data sheets, and participation in Association activities.

P244-52. Pulp and Paper Engineer. Capable of planning and developing complete pulp and paper mill projects and to coordinate technical aspects of world-wide pulp and paper development program. Headquarters in New York. Some traveling required. Unique opportunity for the right man. Send photograph and résumé of experience.

P245-52. Research Director. An old established concern located in the Middle West manufacturing specialty papers has an opening for a man with a thorough background in paper research. Man applying must have real research ability rather than just a laboratory technician.

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C196-52. Experienced Chemist. Many years' research and development experience in papermaking and coating. Experienced also in sales and sales service to the paper industry. Desires position with paper manufacturer in development of improved papers. Will consider employment by chemical manufacturer in sales to the paper industry.

C197-52. Chemical Engineer. 34. Married. 12 years' pulp and paper mill experience in by-product recovery, conservation of materials, product improvement, testing methods, water treatment, and trouble-shooting. Desires position leading to advancement. New England or Middle Atlantic States preferred.

C198-52. Chemical Engineer. 37. M.S. in pulp and paper chemistry. 8 years' technical and practical experience in insulation board and hard board manufacture, process control, and development work in wood-waste utilization. Desires permanent position in supervisory technical or production capacity, preferably in new development. Prefer West Coast location.

C199-52. Technical Graduate. 15 years' technical and practical experience in production and development of fine specialty grades. Desires responsible position with a progressive organization. Will accept a position in either production or management.

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30-103-2	25/75	Polyisobutylene M—160/165 Micro
30-100-3	20/80	Polyisobutylene M—195/200 Micro
30-133-1	30/70	Butyl Rubber—133/35 Paraffin
30-102-7	30/70	Butyl Rubber—155/57 Micro
30-190-1	30/70	Butyl Rubber—190/95 Micro
30-102-10	40/60	Polyethylene HM—135/37 Paraffin
30-104-6	40/60	Polyethylene HM—160/65 Micro
30-100-12	50/50	Polyethylene MM—135/37 Paraffin
30-149-1	50/50	Polyethylene MM—143/50 Paraffin
30-100-7	50/50	Polyethylene MM—170/75 Micro
30-101-8	50/50	Polyethylene MM—195/200 Micro

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LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel, and Events

Pacific

On Sept. 18–19, 1952, the Pacific Section sponsored its Sixth Annual Seminar on "Recent Research on Cellulose and Lignin" which was conducted by Karl Freudenberg, Professor and Director of the Research Institute for Chemistry of Wood and Polysaccharides, University of Heidelberg, Heidelberg, Germany.

The seminar was repeated on Sept. 22–23, 1952, at Bagley Hall, University of Washington, Seattle, Wash.

The following lectures by Dr. Freudenberg served as the basis of discussion at the seminar:

1. "Organic Chemical Work on the Constitution of Cellulose."
2. "Research on Natural Lignin and Its Constitution."
3. "Research on Artificial Lignin and Its Constitution."
4. "Lignification of Plant Tissue and the Lignin-Polysaccharide Linkage."

On Sept. 25–27, 1952, the Pacific Section met jointly at Victoria, B. C., with the Pacific Branch, Technical Section, Canadian Pulp and Paper Association, and the Pacific Coast Division, American Pulp and Paper Superintendents Association. A report of the Victoria meeting will be reported in a later issue of *Tappi*.

Southeastern

On September 19 the Southeastern Pulp and Paper Society received its charter as a local section of the Technical Association of the Pulp and Paper Industry. The presentation was made by R. G. Macdonald, Secretary-Treasurer of the Association. The principal speaker was Raymond S. Hatch, Research Adviser to the Hudson Pulp and Paper Co., Palatka, Fla. Details covering the meeting will be reported in the November issue of *Tappi*.

Subsequent meetings will be held at Jacksonville, Fla., on November 21; at Charleston, S. C., on Jan. 23, 1953; at the Hotel Dempsey, Macon, Ga., on March 20, 1953; and at the General Oglethorpe Hotel, Savannah, Ga., on May 8, 1953.

Ohio

Professor Karl Freudenberg of Heidelberg University, Heidelberg, Germany, was the speaker at the September 15 meeting of the Ohio Section. He discussed "The Formation of Lignin in Plant Tissues." Preceding the evening meeting Dr. Freudenberg conducted an afternoon round-table discussion of the "Chemistry of Cellulose and Lignin."

At the October 14 meeting J. A. Van den Akker of The Institute of Paper Chemistry, Appleton, Wis., discussed "The Measurement of Color." Both meetings were held at the Manchester Hotel, Middletown, Ohio.

During the past Summer the Ohio Section Program Committee met at the Peerless Pantry, Miamisburg, Ohio, on June 10 and at Fort Ancient, Ohio, on July 27 to plan the program for the 1952–53 season.

Harold Joiner of Champion Paper & Fibre Co., is Chairman of the committee. Associated with him are Don Jenkins of Champion, Ellsworth Shriver of Mead Corp., Les McGowan of Sorg Paper Co., R. H. Mosher of Miami Valley Coated Paper Co., William Aiken of Gardner Board & Carton Co., Carl Ireton of Specialty Paper Co., Frank C. Duval of Shartle Bros. Machine Co., and Travis Holden of Howard Paper Mills.

The next meeting will be held on Nov. 18, 1952, at the Manchester Hotel, Middletown, Ohio. This meeting will be held jointly with the Miami Valley Division of the American Pulp & Paper Mill Superintendents Association. The subject will be "Electrical Distribution in Paper Mills."

On April 9, 1953, there will be an inspection trip through the plants of Bauer Bros. Co. and the Crowell Collier Publishing Co. in Springfield, Ohio. There will be a talk on "Rotogravure Printing."

The final meeting will be a Ladies Night at the Hartwell Club House in Cincinnati, Ohio, on May 14, 1953.

Details regarding the December to March meetings will be announced later.

Ed. Note: Since Dr. Freudenberg lectured at several TAPPI local section meetings the following biographical sketch appeared in *Ohio TAPPI*, the excellent publication of the Section:

Karl Freudenberg was born Jan. 29, 1886, in Weinheim, Baden, Germany. His scholastic training was received at the University of Bonn and Berlin. From the latter, he received the Ph.D. in 1910, having studied under Emil Fischer. He stayed with Fischer until 1914 studying gallic acid and tannin-like materials. In 1914 he went to the University of Kiel where he stayed until 1920 with the exception of military service during the years 1914–18. In 1920 he taught at the University of Munich, in 1921 at Freiburg, and 1922 he went to Karlsruhe where he stayed until 1926.

In 1926 Dr. Freudenberg went to the University of Heidelberg as Director of the Chemical Institute and of the Research Institute for the Chemistry of Wood and Polysaccharides. Recently he completed a term as Rector of the University of Heidelberg. Some years ago Dr. Freudenberg spent a year as visiting professor at the University of Wisconsin. Dr. Freudenberg is a member of many learned societies and has carried on researches in a wide variety of fields, most of which might be classified as organic compounds from natural sources.

His researches include publications on such widely diversified subjects as tanning, branched chair sugars, catechin, cellulose, starch, dextrin, insulin, and lignin. Since his appointment at Heidelberg he and his students have published many papers in the field of lignin chemistry. Recently he reported on the synthesis of lignin-like material prepared through the simultaneous dehydrogenation and polymerization of coniferyl alcohol. In 1951 Freudenberg visited the United States to participate in the Jubilee Meeting of the American Chemical Society, the XIIth International Congress of Pure and Applied Chemistry, the International Pulp and Paper Symposium at Appleton, and the Fundamental Research Conference at McGill University. Currently he is speaking before a number of sections of TAPPI as well as the American Chemical Society. He will conduct a seminar for the Pacific Section of TAPPI in both Portland and Seattle under the general title "Recent Research on Cellulose and Lignin."

In addition to his researches and their subsequent publications and his contributions before technical meetings, Dr. Freudenberg is the author of a number of books, the most familiar to members of TAPPI being "Tannin, Cellulose, and Lignin," Berlin, 1933.

Dr. Freudenberg is a very gracious speaker, and possesses the ability to make it possible for the nonspecialist to follow without great difficulty discussions of the fundamental problems in the field of cellulose and lignin chemistry.

Maine-New Hampshire

The Maine-New Hampshire Section will meet at the Lafayette Hotel, Portland, Me., on Nov. 7–8, 1952.

On Friday afternoon, November 7, the following program will be presented:

1. Paper by Ralph Carr, Manager of Technical Service, Mathieson Chemical Co., Baltimore, Md.
2. "Values of Acidic Reducing Agents in Kraft Bleaching," by H. B. Channon, Virginia Smelting Co., Boston, Mass.

3. "High Density Hydrogen Peroxide Systems," by R. L. McEwen, Buffalo Electro-Chemical Co., Buffalo, N. Y.
4. "Modern Washing and Bleaching at S. D. Warren Co.'s Mill," by Robert Nivison, Improved Paper Machinery Co., Nashua, N. H.

In the evening a banquet and entertainment will be held.

On Saturday morning at 8:30 there will be a Get-Together Breakfast. R. T. Greep, Production Superintendent of the S. D. Warren Co., Cumberland Mills, Me., will give a brief talk outlining details to be noted during the tour of the company's mill in the morning. Special attention will be given to the brown stock and bleaching plants.

Room reservations should be made direct with the Lafayette Hotel in Portland.

On October 18 the American Chemical Society will meet at Lincoln, Me. Harry F. Lewis of The Institute of Paper Chemistry, Appleton, Wis., will discuss "Lignin."

New England

The Executive Committee of the New England Section met at Rovelli's in Springfield, Mass., on September 5. The members present were: Harold Knudson, Chairman, Hollingsworth & Vose Co., East Walpole, Mass.; C. I. Horton, R. T. Vanderbilt Co., Norwalk, Conn.; H. T. Barker, Bird & Son, East Walpole, Mass.; George Soyka, Fort Orange Paper Co., Castleton-on-Hudson, N. Y.; Freeman Perry, Chemical Paper Mfg. Co., Holyoke, Mass.; George Wallace III, Fitchburg Paper Co., Fitchburg, Mass.; F. S. Klein, Byron Weston Co., Dalton, Mass.; and F. D. Applegate, Hercules Powder Co., Holyoke, Mass.

Meetings of the Section were scheduled for October 10, November 21, March 20, and a date in May, 1953, which will be held jointly with the Connecticut Valley Division of the Superintendents Association.

The November 21 meeting will be designated "Helen Kiely Night."

The March 20 meeting will be concerned with "Routine Control Methods." George Soyka will be in charge.

The theme for the May meeting will be "Process Efficiencies and Economics."

Delaware Valley

The Delaware Valley Section opened its current season of meetings on September 19 with a visit to the mill of the Container Corp. of America at Manayunk, Pa. In the evening a panel discussion was held at the Engineers Club in Philadelphia. Glen T. Renegar, Superintendent of the Container Corp. mill, acted as Moderator. The panel consisting of Mr. Renegar, Thomas Brookover of the Downingtown Paper Co., Downingtown, Pa., Harold Holcomb, Schmidt & Ault Paper Co., York, Pa.; and George Suydam, Reigel Paper Corp., Milford, N. J., discussed "Cylinder Machines Operation."

The Section has issued an interesting pocketbook size calendar with the meeting dates printed in bold-face type.

The following meetings are scheduled for the balance of the year at the Engineers Club:

Oct. 23, 1952: "Measurement of Paper Properties Important in Offset Printing," by Gordon C. Wheeler, Lithographic Technical Foundation, Chicago, Ill.
December (date to be announced): "Problems in Managing a Paper Mill," by Hugo H. Hanson, W. C. Hamilton & Son, Miquon, Pa.
Jan. 22, 1953: "Development of Paper Properties," panelled by Ward D. Harrison, Riegel Paper Corp., Milford, N. J., Moderator.
March 26, 1953: "Increased Production from Existing Machines," by John R. Curtis, Scott Paper Co., Chester, Pa.
April, 23, 1953: "Paper Defects," panel led by L. P. Thompson, Personal Products Corp., Milltown, N. J., Moderator.
May 28, 1953: "The Edward J. Albert Award Program." Presentation of prize papers.

Photo, Courtesy J. M. Huber Corporation

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Kalamazoo Valley

The 1952–53 season of meetings of the Kalamazoo Valley Section started on October 2 with a panel discussion on "Management's View of the Technical Department."

The schedule of meetings which are held at the Hotel Harrison in Kalamazoo for the balance of the year is as follows:

Nov. 6, 1952: "Beater Loading-Clay and Titanium Dioxide."
Dec. 4, 1952: "Production Control in Printing; Quality Control in Pulp Manufacture."
Jan. 15, 1953: Joint meeting with the Michigan Division of the Superintendents Association.
Feb. 5, 1953: "Fiber Treatment for Strength Development" by James d'A Clark, Consulting Engineer, Longview, Wash.
March 19, 1953: Graphic Arts. Joint meeting with the Michigan Division of the Superintendents Association.
April 2, 1953: "Sizing-Rosin, Starch, and Synthetic Chemicals."
May 7, 1953: Senior Thesis Presentations by Students of Western Michigan College.
June 1953 (date to be announced): Election of Officers, Annual Fun Day.

Chicago

"Paper at Work" was the subject of a paper presented by C. H. Runyan, Field Secretary of the Graphic Arts Association of Illinois, Chicago, Ill., on Sept. 18, 1952.

Lake Erie

The Lake Erie Section held a Summer meeting on Aug. 22, 1952, at the Ridgeway Country Club in Cleveland, Ohio. The golf and softball party and dinner were preceded by a visit to the plant of Greetings Corp. in Cleveland.

On September 19 the Section met at the Carter Hotel in Cleveland. Elroy L. Stromberg of the Department of Psychology, Western Reserve University, Cleveland, gave a talk on the subject "They're Always Judging Me."

The schedule of programs for the balance of the season is as follows:

Oct. 17, 1952: "What Printing Process for the Job."
Nov. 21, 1952: "Packaging Engineering."
Dec. 12, 1952: Christmas Party.
Jan. 16, 1953: "Testing and Quality Control."
Feb. 20, 1953: "Cost Saving Equipment for Today and Tomorrow."
March 20, 1953: "Surface Characteristics for Printing."
April 17, 1953: "General Maintenance for the Converter."

Empire State

The Summer meeting of the Empire State Section will be held at Whiteface Inn, Lake Placid, N. Y., on June 8–10, 1953.

Northern District

The meetings of the Northern District of the Empire State Section started on October 9 in Watertown, N. Y. J. S. Illick, Dean Emeritus of the College of Forestry, State University of New York, Syracuse, N. Y., gave a talk on "Our Natural Resources."

The schedule of meetings for the balance of the year is as follows:

Nov. 13, 1952: "The Legislative Aspects of Forests in New York State." A panel discussion led by Assemblyman Benjamin Demo, Moderator.
Dec. 11, 1952: "The Utilization of Hardwoods," by a representative of the Forest Products Laboratory, Madison, Wis.
Jan. 8, 1953: "What Holds Paper Together," by Wilfred Galley, E. B. Eddy Co., Hull, P. Q.
Feb. 12, 1953: Annual Ladies Night, Valentine Dance, and Entertainment.
March 12, 1953: "Sell for America," by W. F. Luckenbach, Jr., Manager of the Industrial Sales Dept., Virginia Smelting Co., West Norfolk, Va.
April 9, 1953: "Recent Developments in Paper Machine Drives," by a representative of the Westinghouse Electric Corp., East Pittsburgh, Pa.

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Central District

The Central District of the Empire State Section opened its series of monthly meetings on October 3 at the University Club, Syracuse, N. Y. J. Walter Couture, Chief Engineer of the Dilts Machine Works, Fulton, N. Y., discussed "Ultra Precision Coating of Traveling Webs."

The schedule of meetings for the balance of the year is as follows:

Nov. 7, 1952: "Evaluating the Quality of the Water of the Oswego River," by Durwood Gefkin, Chief Chemist, Oswego Falls Corp., Fulton, N. Y.
Dec. 5, 1952: "Beating—An Old Angle," by Hilliard D. Cook, General Superintendent, Sweet Bros. Paper Mfg. Co., Phoenix, N. Y.
Jan. 9, 1953: "Control of Microbiological Growths in Pulp and Paper Mills," by Ernest Reed, Dean of the College of Plant Sciences, Syracuse University, Syracuse, N. Y.
Feb. 6, 1953: Talks by E. C. Jahn, Assistant Dean, and Fred O'Neil, Professor of Pulp and Paper, College of Forestry, State University of New York, Syracuse, N. Y.
March 6, 1953: John Spaulding, Technical Director, Marathon Corp., Oswego, N. Y. (Subject to be announced.)
April 3, 1953: Fred G. Sommerville, Chief Chemist, Armstrong Cork Co., Battle Island Division, Fulton, N. Y. (Subject to be announced.)
May 1, 1953: Address to the senior students of the College of Forestry, State University of New York by R. G. Macdonald, Secretary-Treasurer of the Technical Association of the Pulp and Paper Industry, New York, N. Y. (Subject to be announced.)
June 5, 1953: Annual Election of Officers and Ladies Night.

Western District

The Western District of the Empire State Section has announced its 1952-53 schedule.

Meetings will be held at the Prospect House, Niagara Falls, N. Y., on Oct. 1, 1952, Nov. 5, 1952 (joint meeting with the Niagara Branch, Technical Section, Canadian Pulp and Paper Association), Dec. 3, 1952, Feb. 4, 1953.

In March, 1953, the joint meeting will be held at a Canadian location with the Niagara Branch. On April 1, 1953, the Annual Election of Officers and Ladies Night will be held at the Park Hotel, Lockport, N. Y.

Metropolitan District

The Metropolitan District of the Empire State Section met at Fraunces Tavern, New York City, on Oct. 14, 1952.

Eastern District

The Eastern District of the Empire State Section held a program planning meeting at the Queensbury Hotel, Glens Falls, N. Y., on September 11.

The first meeting of the year is scheduled to be held on Oct. 16, 1952, at Milfrank's Restaurant, Glens Falls, N. Y. The topic for discussion will be "Corrosion."

The Officers of the Eastern District are: Chairman, R. E. March, Marinette Paper Co., Fort Edward, N. Y.; Vice-Chairman, John Crocker, Sandy Hill Iron & Brass Works, Hudson Falls, N. Y.; Secretary-Treasurer, G. H. Hocking, Socony-Vacuum Oil Co., Albany, N. Y.; Entertainment Chairman, Gerald Roider, International Paper Co., Palmer, N. Y.; Program Chairman, Grant Cole, Diamond Match Co., Plattsburg, N. Y.; and Publicity Chairman, Clyde Davis, Finch, Pruyn & Co., Inc., Glens Falls, N. Y.

Lake States

The first meeting of the Lake States Section was held at the Conway Hotel, Appleton, Wis. Prof. K. Freudenberg, Heidelberg University, Heidelberg, Germany, gave a lecture on "The Formation of Lignin in Plant Tissue."

Following is the schedule of meetings for the balance of 1952-53:

Nov. 11, 1952: Afternoon tour of The Institute of Paper

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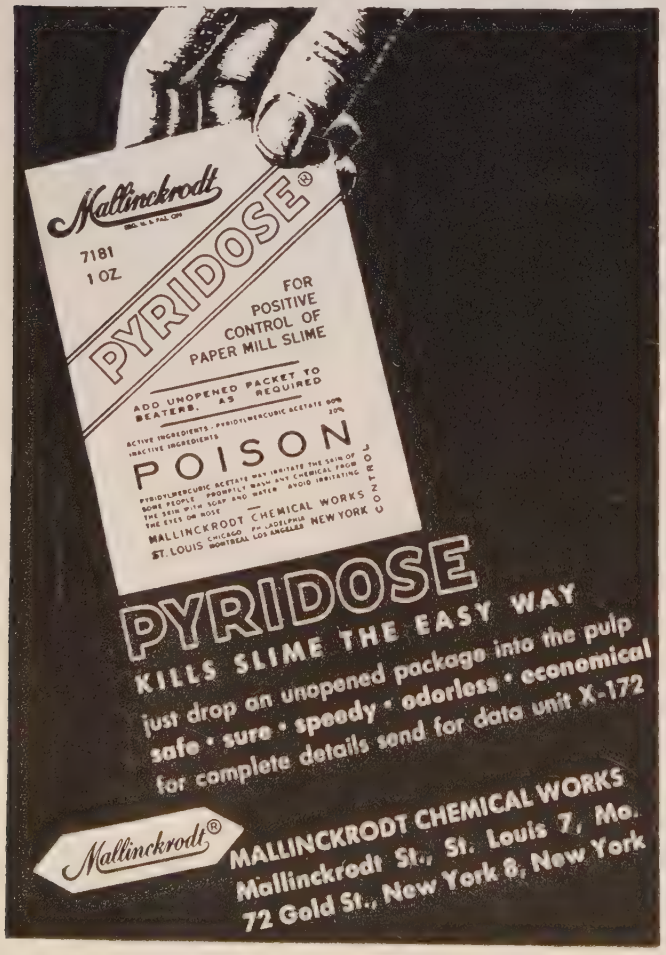
Chemistry, Appleton, Wis. Panel Discussion on "Papermaking Properties of Fibers."
Jan. 13, 1953 (Hotel Conway, Appleton, Wis.): "Stainless Steel in the Paper Industry."
March 10, 1953 (Green Bay, Wis.): "Savealls."
April 15, 1953 (Elks Club, Wisconsin Rapids, Wis.): Tour of the mill of the Nekoosa-Edwards Paper Co., Port Edwards, Wis. "Fourdrinier Operation and Paper Defects Attributable to Same."
May 12, 1953: Annual Meeting. Election of Officers and Social Program.

Southern California

The Papermakers and Associates of Southern California meet on alternate months at Ivan's Restaurant, Los Angeles, Calif.

The Summer meeting was held on July 17. A panel session of "Maintenance" featured the meeting. "Converting Equipment and Machinery" was discussed by Sherwood Wieman, Fibreboard Products, Inc., Los Angeles; "Power Plant Maintenance" by Henry Hill of Pioneer-Flintkote, Inc., Los Angeles; and "Paper Machinery and Drives" by Al Hatch and Les White, Container Corp. of America, Los Angeles.

On September 18 a panel session was held on "Printability of Board." The members of the panel were: Otto Sass, Pioneer-Flintkote, Inc., Los Angeles; William Richards, Container Corp. of America, Los Angeles; Aaron Miller, Kelco Co., Los Angeles, and Herbert Brigden, Fibreboard Products, Inc., Los Angeles.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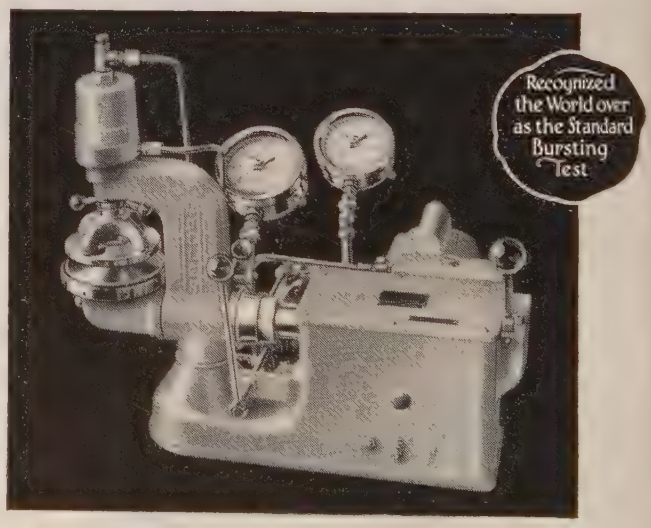

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I. The STFI "Stress-Strain Recorder"

KEITH W. HARDACKER, W. A. WINK, and J. A. VAN DEN AKKER

Following a brief description of the STFI "stress-strain recorder," the results of a general inspection of the instrument are discussed. Many of the features of the instrument are good and well planned. The recording drum is of ample size and is so designed that handling of the drum, chart paper, and other matters relating to routine testing may be done with facility. The course of a recording may be controlled, at will, from the control panel by the simple pushing of buttons, or, alternatively, the direction may be reversed by the presetting of switches operating on either load or elongation; the instrument is adequately protected by means of several limit switches, and the machine turns itself off at the conclusion of a test. Some of the observed errors of design or of construction are of the kind which one normally expects to find in an instrument which has not long been in production, but may easily be eliminated in new issues of the instrument. Without correction (correction was made where feasible for the purposes of the present study), these errors could have resulted in serious discrepancies. For example, misalignment of the jaws resulted in a very nonuniform stress distribution in paper specimens; the weighing beam was not free when the instrument was unpacked and prepared for use, because of an error in the construction of the beam support which resulted in displacement during shipment; the frame of the instrument is sufficiently flexible that, on locking the specimen chamber door (after freeing the beam), the distortion of the frame was sufficient to inhibit the free movement of the beam; the light beam for control of the chain motor was not in proper adjustment when the instrument was received; and careful adjustment of the amplifier had to be made to obtain suitable recordings. In later work it was found that one of the jaw faces in the lower jaw assembly had been improperly designed, and concentrated the clamping load in a small spot, giving rise to nonideal performance, particularly in the case of thin, relatively incompressible papers. Recorded curves showed that imperfections of the screws for driving the lower jaw assembly and the pen introduced, respectively, long waves and fine waves in the load-elongation curves. The latter were not considered to be of serious magnitude. Basic limitations of the equipment were found in the rate of elongation and in the maximum load which the weighing system can exert. The instrument produces only one rate of elongation, and that rate is quite low, being 0.75 mm. per min. (or 0.03 in. per min.) when the instrument is operated on a 60-cycle power line. The instrument studied in the present work was equipped with the heaviest chain (0 to 10 kg. loading), but the largest load which the instrument could exert and record was found to be only 17 lb. (7.7 kg.). Load-elongation curves were obtained for a series of papers by means of both the STFI load-elongation equipment and the Baldwin-Southwark universal testing machine (with the latter operating at the same span and rate of elongation). The means of the curves were observed to be in generally good agreement, the differences being accountable by sample variability.

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THE importance of the tensile and stretch properties of paper have been discussed in Report No. 29, Part I (*1*); in particular, the value to technology of the load-elongation relationship of materials generally was discussed, just ten years ago, in Report No. 36 (*2*), in which it was stated, "Engineers in their study and use of structural materials, and the textile industry have relied on load-deformation curves for many years; the paper industry may be 'missing a bet' by not doing the same." The results of studies of three tensile testers have been presented in Parts II, III, and IV of Report No. 29 (*3*). In more recent years, Steenberg and his associates have amply demonstrated the importance, in both fundamental and applied work, of the load-elongation characteristic of paper (*4–10*). Their work was done by means of a "stress-strain recorder" of their own design and construction. Subsequently, the firm of Lorentzen and Wettres Maskinaffär, of Stockholm, undertook the commercial design and construction of this instrument. Through the kindness of Lorentzen and Wettres, one of these new instruments was shipped to Appleton, on a loan basis, for study. The manufacturers were also kind enough to agree to inclusion of the instrument on the APPA instrumentation program. This report presents the results of the study.

DESCRIPTION OF THE INSTRUMENT

Photographs of the STFI load-elongation equipment, showing a general view and a close-up of the beam system with the hood and a side cover removed are reproduced in Figs. 1 and 2. These views were taken of the instrument as installed for study in one of the constant-temperature, constant-humidity rooms of the Institute. A full technical account of the instrument will not be presented herein, because the authors of the method have already published the details (*4*), and because the manufacturers present an adequate technical description, together with electrical and mechanical diagrams, in their instruction manual. The following description will suffice for the purposes of this report.

The specimen under test is continuously weighed by means of an automatically controlled chain balance. With reference to Figs. 1 and 2, manual manipulation of the knob A is first done to disengage the micrometer screw (to which the lower jaws are connected) from the strain motor. The knob is turned by hand until the micrometer screw sleeve B indicates that the lower jaws C are in their zero position. Then, before in-

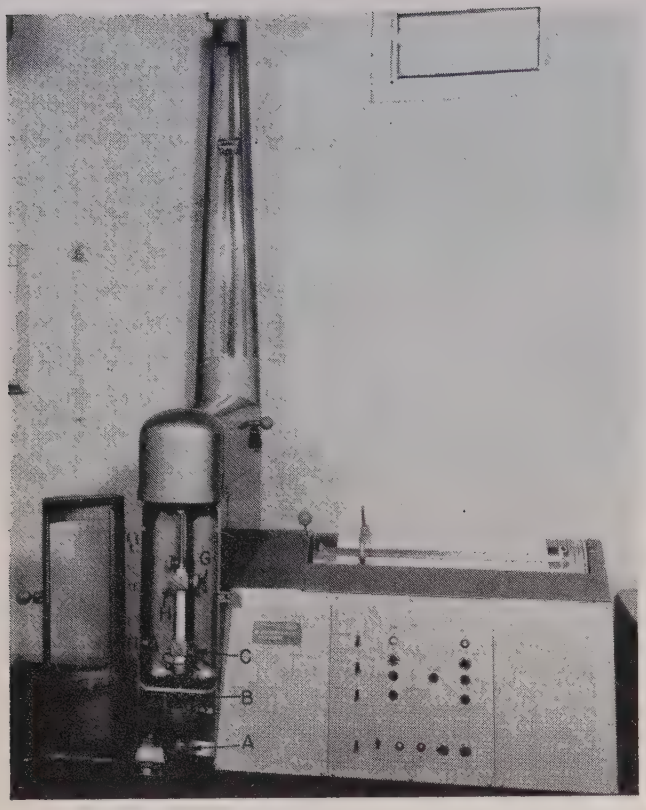

Fig. 1. Photograph showing a general front view of the STFI "stress-strain recorder"

serting the specimen, the chain motor is switched on; this motor, which raises and lowers the back end of the chain in the tower of the instrument, is controlled by the position of the beam. This is effected by means of a light beam which originates in a small lamp within the lamp house D, a thin metal "chopper" E mounted on the beam, and a phototube within the housing F. If, at any moment, the chain momentarily supplies too much load, the beam and the chopper will be below the balance position, the light beam will deliver more flux to the phototube than that for balance, and the output of the phototube amplifier will so actuate a relay that the chain motor will be driven with full electrical potential applied in the direction to lift the chain. As the weight exerted by the chain lessens, the rear end of the beam and the attached chopper rise, and the fine line of light in the plane of the chopper becomes intercepted, with the result that the relay is moved to its other position, and the chain motor is suddenly supplied with full potential for movement in the reverse direction. Thus the chain motor, the chain system, and the beam oscillate; the beam oscillates through a narrow range corresponding to the chopping of the thin beam of light.*

With, as yet, no specimen in the instrument, the back end of the chain is at its highest point in the tower. The recording drum rotates by connection (through change gears) to the chain motor. Thus, at the moment, the drum is at its zero position. The chain motor is now switched off, and the upper jaws are momentarily clamped in position through the turning of screw G. This causes the arms of a clamping yoke to close in upon the sides of the upper jaw assembly. The test strip of paper is then inserted in the jaws in conformity with instructions, and the jaw-holding yoke is disengaged. Then the chain motor and the strain motor, which cause the lower jaws to move downward, and the pen motor, which causes the pen to move parallel to the axis of the recording drum, are switched on. These motors are presumably synchronous, so that the motion of the pen is considered to be equivalent to the magnified motion of the lower jaws. By design, the motion of the pen should be 50 mm. for 1 mm. movement of the lower jaws. As the specimen becomes elongated, the load supplied to the back end of the beam automatically increases by lowering of the chain through unwinding of the fine steel cables from the drums I; these drums are driven by the chain motor. The beam has a mechanical advantage of 15. One of the results of this fairly large ratio of lever arms is that the perceptible hunting of the back end of the beam produces only a small oscillation in the elongation of the specimen. The load-elongation curve is recorded on the chart until the point of rupture is attained, when the beam falls upon a microswitch J which shuts off the whole system.

However, the instrument is equipped with switches on the elongation and load axes which enable the operator to perform such operations as automatic reversal of the strain and pen motors at predetermined elongation or load, automatic restoration of the original direction of elongation when the load falls to a predetermined value, independent control of the direction of travel of the strain and pen motors, reversal of the direction of the strain motor at will from the control panel, turn off the strain motor alone so that the instrument will record a relaxation curve, and so on. The instrument is fully protected with limit switches and fuses.

If it were not for a fine steel wire linking the back end of the beam with a fixed point on the frame, the frequency of oscillation would be infeasibly low, and it seems likely that the hunting would be severe. This wire, which is adjustable in length, causes the oscillation frequency to be of the order of 4 cycles per sec.

The manufacturers state that the system is a "servo-

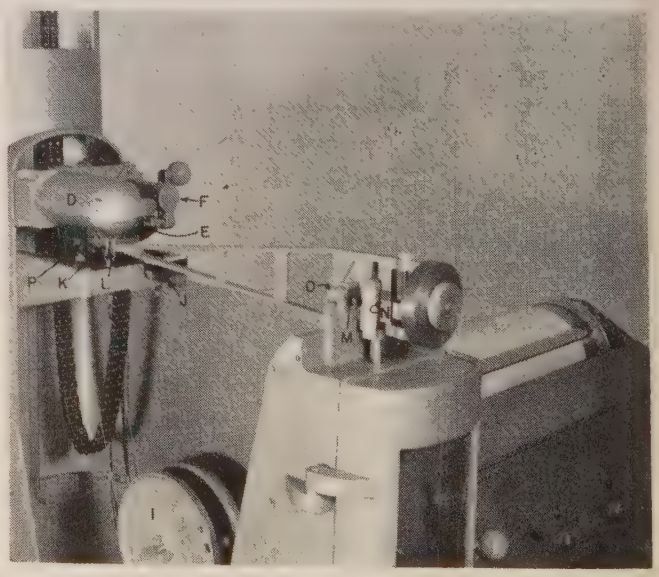

Fig. 2. Photograph showing a close-up view of the chain balance, the beam of the weighing mechanism, and related parts

This view was taken with the end-cover and hood removed.

* The manufacturers have recently perfected simple electrical contactors which replace the optical system and phototube; the electrical contactors cause on and off signals to be sent to the amplifier.

controlled chain balance." Many technical people today, would prefer to reserve the term "servo" or "servomechanism" for automatic control devices which involve negative feed-back, and produce a correction that is instantaneously proportional to the corrective demand. The automatic control system of the STFI instrument is of the open-cycle type; the chain motor receives full driving potential in one direction or the other, as the instantaneous need demands.

The normal specimen width is 15 mm. Two separate upper clamps having different stem lengths and differently located holes for connection enable the operator to employ spans of 5, 10, 15, and 20 cm. The rate of elongation is fixed at one value, the exact rate depending on the frequency of the power line; for 60 cycles per sec., the rate (see later discussion) is about 0.75 mm. per min. According to the manufacturers, the chains with which the instrument may be provided furnish load ranges of 0 to 2, 0 to 4, and 0 to 10 kg. The instrument studied in the present work was equipped with a 0 to 10 kg. chain, although the actual load range was observed to be less than 10 kg. (see later discussion).

Provision is made (Fig. 1) for enclosing the specimen space and for circulating conditioned air through that space. The door which closes this space is gasketed and all the metal parts are said by the manufacturer to be noncorrosive.

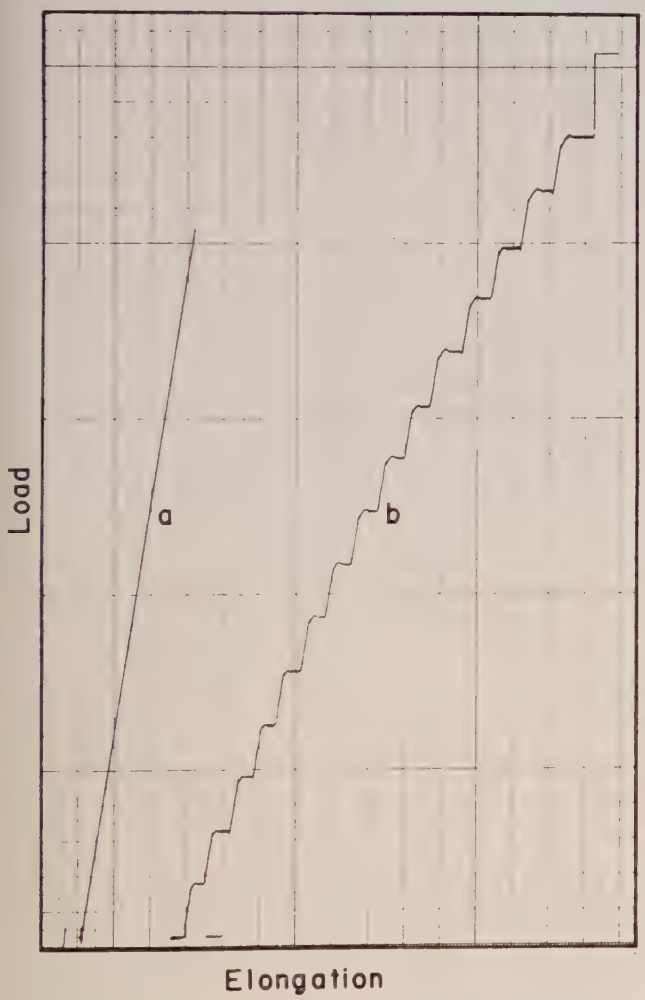

Fig. 3

(a) Recorded trace obtained with the STFI instrument with the pen motor switched on and the chain motor running at full speed; this indicates a rate of loading somewhat greater than the maximum rate at which the instrument can record load versus elongation with accuracy. (b) Recording obtained with dead-weight loadings, with 1-lb. increments (see text for procedure); the topmost level (just under 17 lb.) represents the maximum load which the instrument can exert.

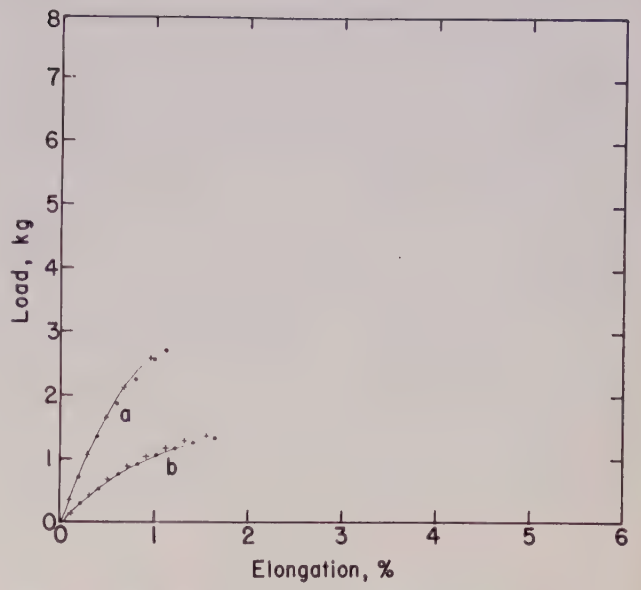

Fig. 4. Load-elongation curves for a groundwood paper

a—machine direction; *b*—cross-machine direction. Circles: STFI averages; crosses: Baldwin-Southwark averages.

GENERAL OBSERVATIONS

During the setting up of the STFI load-elongation recorder and during the course of work with the instrument, several observations were made with regard to maladjustments, and imperfections of design and construction. It should be emphasized that some of these are to be expected in an instrument which has not been fabricated over a long period of time, and may easily be eliminated by the manufacturer in future instruments.

The instrument is to be located on a firm, vibration-free table in a room of controlled atmosphere. The table should have a hole for the free movement of the chain; in our temporary installation, the instrument was mounted on two stout tables which were rigidly fastened together (to avoid cutting a hole in a laboratory table). The installation was made in a constant-temperature, constant-humidity room. There was no perceptible vibration in the support at any time; the effects of vibration were not explored because of the highly arbitrary nature of locally induced vibrations with regard to direction, frequency, and magnitude.

The instrument should be leveled by adjustment of two of its three supports, using a plumb bob suspended at the rear of the tower. The index was loose, however, and other means were employed for the leveling. One of these was the idealized condition that the upper jaws should hang directly above the lower jaws. These means were employed to bring the instrument to a feasible condition of leveling but, during the course of this work, it was noticed that the yoke which holds the upper jaws for insertion of the specimen was misaligned with respect to the lower jaws to such an extent that, with a paper specimen in place and under tension, the tension stress varied from one edge of the strip to the other. Thus, if one edge of a specimen was plucked, the pitch of the tone emitted was very different from that of the tone given off when the other edge was plucked. This was not the result of imperfections of a

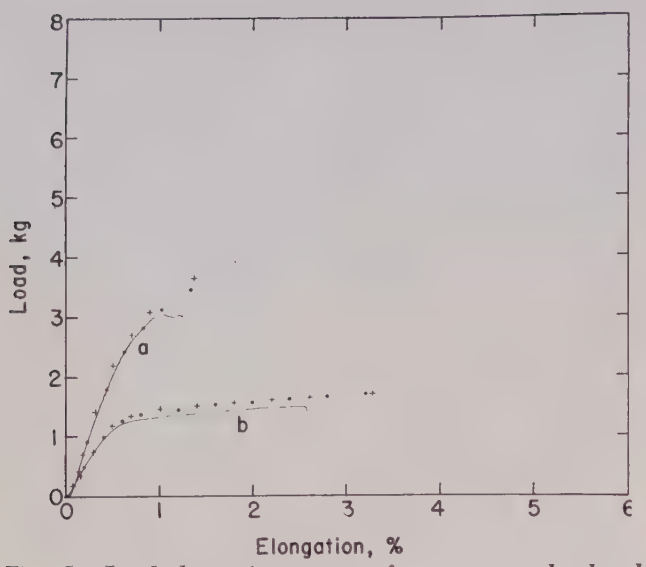

Fig. 5. Load-elongation curves for a supercalendered glassine

a—machine direction; *b*—cross-machine direction. Circles: STFI averages; crosses: Baldwin-Southwark averages. In the recording of curve *a*, the specimen broke in the lower jaws.

single specimen, but was observed for a number of specimens. Since nonuniform stress distribution leads to erroneous results, the condition was corrected in the following way. The yoke, as well as a second yoke which serves to prevent rotation of the lower jaws, is mounted on a round post which is located behind the jaws and is connected to the bottom and top of the specimen chamber. This post has a milled V-slot to position the clamping yoke as it is moved up or down to follow upper jaw placements for different spans, and it also has a milled flat at the bottom for rotational alignment. It was necessary to loosen the lower guide yoke, turn the shaft, reclamp the shaft using shims under one side of the flat, and realign and fasten the guide yoke. While making these corrections it was noticed that the V-slot follows a slightly helical path around the axis of the post (instead of being parallel with the axis). The main knife-edge bearing was made level. The upper jaws are freely suspended with regard to the two principal horizontal axes and, when the adjustments were completed, the upper jaws hung directly over the lower jaws (before and after clamping) with regard to left and right position, but not with respect to front and rear position. The latter could not be achieved because, to effect it the instrument would have to be tilted to the point at which the chain would rub against the front of the tower.

The chain was installed with little difficulty, but it was observed that the two fine steel cables which support the chain and cause it to move up and down had unequal tension. There was reluctance to adjust the drums I (Fig. 2) or the points of attachment of cables to the drums. A simple screw at the fixed end of either cable (at the top of the tower) would enable the operator readily to equalize the tensions. The tension was nearly equalized by shifting the cable clamping point, but the equalization failed to hold over the whole range of the chain travel because of a tendency of the chain to twist. This twist is probably due to the circumstance that the beam does not point directly at the suspended portion of the chain, but slightly to one side.

One aspect of the chain which was found to be awkward was difficulty at the lower limit switch (which serves to stop the chain motor when the chain reaches the bottom of its travel). This switch is activated by means of a two-fingered yoke which fits around the chain and catches the chain pulley cradle when the chain is lowered. The separation of the two fingers is not great enough to prevent frequent snagging of the yoke by the chain (at either side of the chain). When this snagging occurred during the upward movement of the chain, the yoke was bent out of shape and, in one instance, it was clear that the yoke was sufficiently bent that the limit switch would not have been properly activated, had the need for the switch arisen at the time.

When the instrument was connected to the 120-volt power line (the instrument was equipped with a transformer to provide the normal operating potential of 220 volts), it was found that the frame of the instrument was "hot," probably because of leakage currents. Provision should be made for automatic grounding of the frame (as with most modern American devices) when plugged in. Users of the STFI load-elongation recorder should have a supply of fuses, neon indicator lamps (two of which burned out during the present study) and, perhaps, other parts which might be difficult to replace readily in this country.

Shipping of the instrument caused no visible damage to the equipment, which was very well crated. However, the beam (Fig. 2) had been shifted with respect to the main fulcrum (knife edge) to the point where the small guide rod K on the back end of the beam rubbed against the side of the U-shaped guide L mounted on the frame of the instrument. The beam contains a hardened steel T-shaped piece which has V-shaped slots engaging the main fulcrum and the knife edge supporting the upper jaws. This T-shaped piece (M in Fig. 2) is supposed to be gripped in the beam by the wedging action of two small tapered pins below the piece. However, one of these pins N had been improperly located and failed to hold the piece firmly. A corrective adjustment was made, so that the beam would move freely; this was partly facilitated by adjustment of the

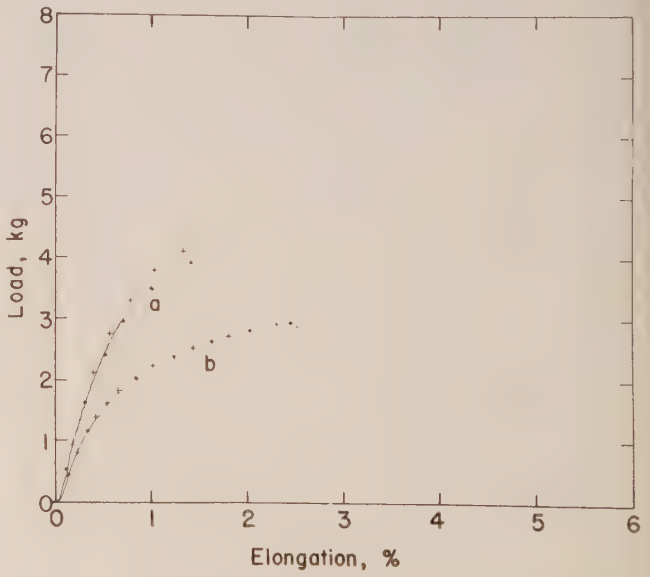

Fig. 6. Load-elongation curves for an uncalendered coated paper

a—machine direction; *b*—cross-machine direction. Circles: STFI averages; crosses: Baldwin-Southwark averages.

screws O, which permit a little movement parallel to the main fulcrum. In spite of these corrections, trouble was still encountered, for the main frame of the instrument is sufficiently flexible that the laying of a hand on almost any portion of the instrument, or locking of the door of the specimen chamber, would produce enough distortion to cause the guide L and the guide rod K to contact. Freedom of the beam movement for all conditions of operation was finally achieved by making a new guide L having a slot of about twice the width of that of the original guide.

The light beam was found to be focused in a plane within the phototube housing rather than in the plane of the chopper. The proper adjustment was easily made.

On checking the amplifier, it was found that the chain motor relay failed to operate as described in the instruction manual. After gaining access to the relay and inserting a milliammeter in the circuit, the relay energizing current was observed for the up and down positions of the chopper. According to the manual, the energizing current should be at least 12 ma., and the relay should release when the current falls to 9 ma. Adjustment of the amplifier is made by means of a potentiometer rheostat mounted on the chassis of the amplifier (access from rear cover); this rheostat is probably a gain control. The manual recommends a setting of 80 to 85 when the instrument is operated on a 50-cycle line and a different setting (not specified) when the operation is on a 60-cycle line. The control was found to be set at 100. When the relay was energized, it was observed that the current slowly oscillated from 8 to 14 ma. (with a period of about 2 sec.); however, the relay did not release when the current fell to 8 ma. The behavior of the relay was then observed for various line voltages (varied in steps from 105 to 121 volts, the latter being the line voltage usually existing in the testing room) and for various settings of the control. Optimum performance was obtained (for the line voltage of 121 volts and 60 cycles per sec.) with a control setting of 70; the on and off relay currents were then 14.4 and 1.8 ma.

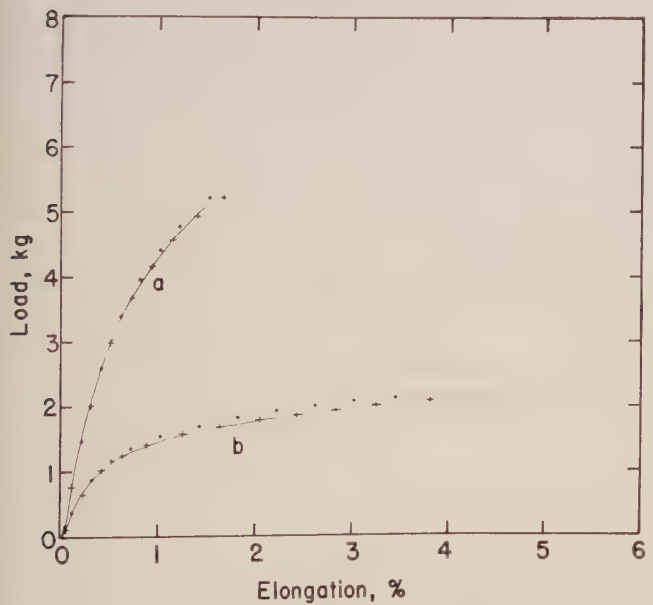

Fig. 7. Load-elongation curves for a supercalendered coated paper (not the same stock as that involved in Fig. 6)

a—machine direction; *b*—cross-machine direction. Circles: STFI averages; crosses: Baldwin-Southwark averages.

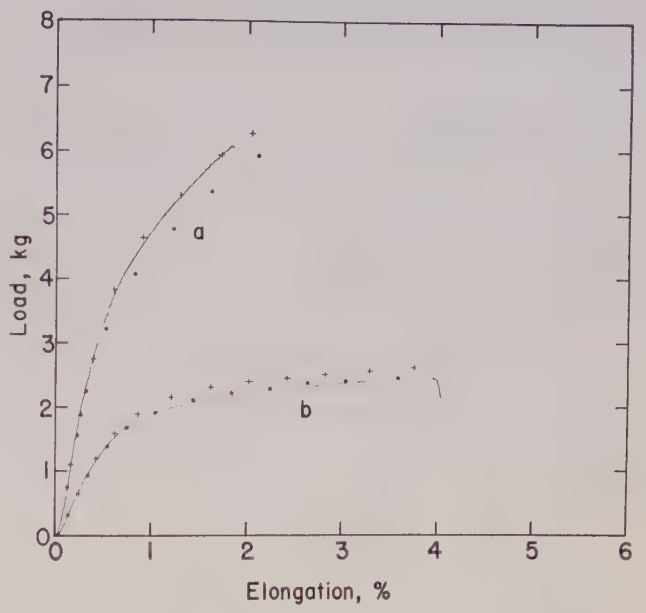

Fig. 8. Load-elongation curves for a 25% cotton bond paper

a—machine direction; *b*—cross-machine direction. Circles: STFI averages; crosses: Baldwin-Southwark averages.

The adjustments of the vertically and horizontally adjustable weights on the beam were checked and found to be satisfactory.

OBSERVATIONS ON THE ELONGATING SYSTEM

The rate of elongation was determined by measuring the time required for the lower jaws to move from a micrometer screw reading of 20 to 15 mm. The observed time was found to average 401 sec. for a line voltage of 105 or 117 volts. This yields a rate of 0.75 mm. per min.

By design, the rate of elongation should be constant, for the upper jaws are maintained at a constant elevation. However, it was felt that nonrigidity of the frame might result in variability of the relationship between elongation and pen travel when the instrument is under load. This was tested in the following way. A very thin column will commence to bend while under a compressive axial load when the load is equal to that calculated by the well-known Euler equation for thin columns. The nature of the relationship between the degree of bending and the load is such that, from impending bending to mild bending, the load is almost constant. If, now, with a specimen of paper in the jaws, two very thin Euler columns of different length (but each of length greater than the initial separation of the pairs of jaws) are bowed and inserted between the two jaw assemblies, and a test run is made, the shorter of the two will straighten and suddenly cease to exert its thrust when the span is just equal to its straight length, and the longer will subsequently straighten and cease to exert its thrust when the span becomes equal to its length. Such Euler columns were fashioned from straight lengths of piano wire, the ends of which were ground round. The lengths of these wires, which were prepared for testing with an initial span length of 100 mm., were measured with a Gaertner spectrum plate comparator, and found to be 100.28 and 102.09 mm. Thus, the sudden increments occurring in

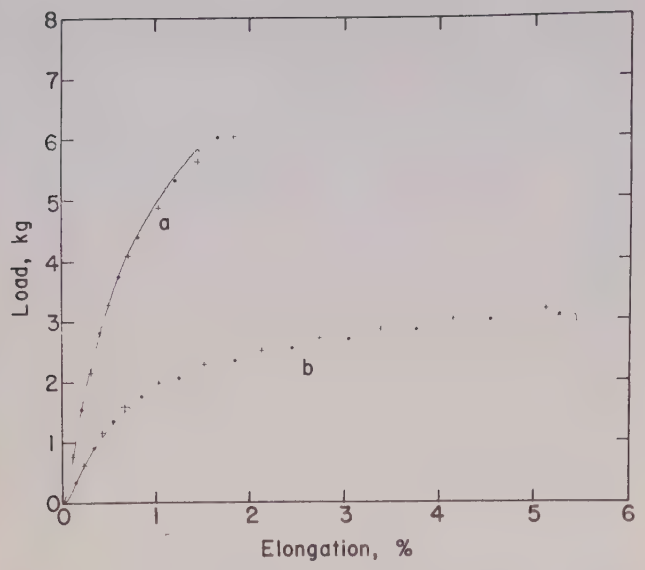

Fig. 9. Load-elongation curves for a sulphite tablet paper

a—machine direction; *b*—cross-machine direction. Circles: STFI averages; crosses: Baldwin-Southwark averages.

the recorded load-elongation curve corresponding to the points of abrupt straightening of the two wires should occur at spans differing by 1.81 mm. This test was performed several times over an approximately fourfold load range. Correction was made for the fact that 100 divisions of the particular chart paper employed in the work had an actual length of 100.34 mm. The distances between the abrupt increments appearing on the recordings were divided by 1.81 to obtain the data presented in the last column of Table I for the actual pen travel, in millimeters, for 1-mm. change in span under typical testing conditions.

By design, the pen travel per millimeter change in span should be 50.0 mm. per mm. Thus, the effect of loading is evidently a distortion of about 0.6% (actual distortion in the frame around the elongating system of the order of 0.006 mm. per millimeter change in span). This is regarded as a satisfactory level of accuracy in the elongation-indicating system.

The chief criticism of the elongation aspect of the instrument—indeed, an important criticism of the instrument as a whole—is the very low rate of elongation. For a span of 100 mm., the rate of 0.75 mm. per min. corresponds to only 0.75% per min. Thus, if the maximum extensibility ("stretch") of a paper specimen is 9%, the time required to record the load-elongation characteristic is 12 min. Aside from the matter of slowness of testing, the rate of straining would seem to be much too low to simulate the conditions of many use requirements. The problem lies not so much in the mechanism for moving the lower jaw assembly as in the inability of the automatic weighing system to follow more rapid development of load (see later discussion). Some of the domestic load-elongation recorders are capable of substantially greater rates of recording.

Table I Relationship Between Pen Travel and Span

Specimen width, mm.	*Chart interval, div.*	*Actual pen travel, mm.*	*Actual pen travel/mm. of span*
7.5	90.4	90.7	50.1
7.5	90.8	91.1	50.3
15.0	89.7	90.0	49.7
15.0	90.4	90.7	50.1
15.0 (2)[a]	91.2	91.5	50 6
15.0 (2)[a]	91.6	91.9	50.8
		Average:	50.3

[a] Two 15-mm. specimens.

Table II. Calibration of the Weighing System

Weight, lb.	*Chart distance, div.*	*Div./lb.*
1.00	15.0	15.0
2.00	30.0	15.0
5.00	75.0	15.0
10.00	151.0	15.1
15.00	228.0	15.2

OBSERVATIONS ON THE WEIGHING SYSTEM

With the gear setting (between the chain motor and the drum) employed in this work, the manufacturers state that 1 mm along the load axis corresponds to 34 grams. This, and the internal consistency of the calibration, were checked through the use of specially cast lead weights. A hole through the center of each weight allowed it to be mounted on the stem of the 5 and 10-cm. span upper jaw assembly (removed from the instrument) so that the combination could be suspended by a strip of paper clamped between that pair of jaws and the 15 and 20-cm. jaw assembly, which occupied the upper position (suspended from the beam). Five weights were made and adjusted to 1.00, 2.00, 2.00, 5.00, and 10.00 lb., so that increments of 1 lb. were available. The steps followed in obtaining curve b of Fig. 3 were:

1. With the chain motor off, the long-stemmed jaw assembly was suspended from the upper jaws by way of a strip of paper.
2. The chain motor was started and the beam thereby brought into balance.
3. The pen motor was started to make a horizontal trace on the chart.
4. Both motors were stopped and a weight was added to the suspended jaw assembly.
5. Both motors were then started simultaneously and run

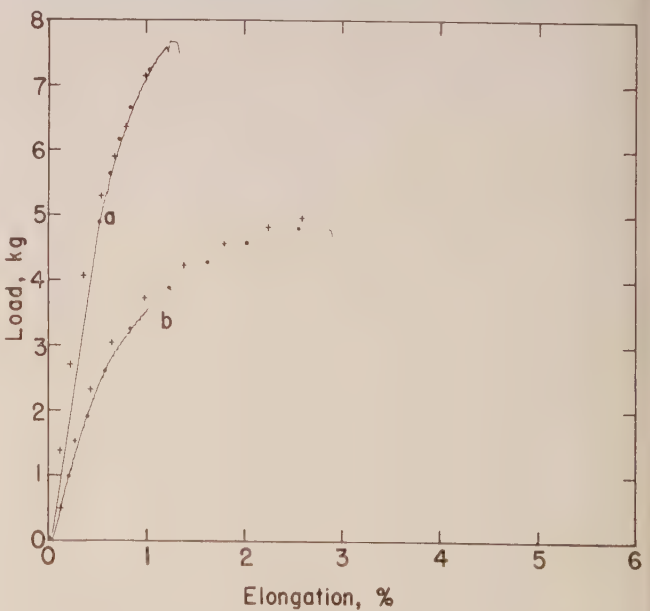

Fig. 10. Load-elongation curves for a blotting paper

a—machine direction, 11.8-mm. strips; *b*—cross-machine direction, 11.8-mm. strips. Circles: STFI averages; crosses: Baldwin-Southwark averages. The rate of increase of load corresponding to the first portion of curve *a* was too great for the STFI weighing system to follow.

until the beam again became balanced, and a horizontal trace was recorded.

6. Steps 4 and 5 were repeated as additional weights were added to the suspended jaw assembly.

Measurements made on the chart (in terms of chart divisions, which are nominally millimeters) are given in Table II. It was determined that 100 divisions on the chart in the direction of the load axis were actually 100.06 mm. Accordingly, the load corresponding to 1 mm. in the direction of the load axis is $453.6/(15.1 \times 1.0006) = 30.0$ g. per mm. The internal consistency of the calibration data is considered to be fair, with the maximum deviation being of the order of 2.6% (the last load increment of 5 lb. yields 15.4 div. per lb. as compared with 15.0 div. per lb. for the first 5-lb. increment).

It should be noted that, in curve b of Fig. 3, the recording did not rise to the proper load indication and then break sharply into a horizontal run, but decelerated in the last stage of the approach and then overshot slightly before attaining the balance point. This is probably the result of the action of the fine steel wire at the back end of the beam; this wire tends to pull the beam into the balance position and can do so when the chain has nearly, but not quite, balanced the beam.

The highest step in curve b of Fig. 3 was obtained by blocking the light beam and permitting the chain to run to its lower limit. This determines the maximum load that the instrument can handle, which is seen to be about 16.7 lb.

The maximum load which the equipment can handle, about 17 lb. in the case of the instrument studied, is felt to constitute a serious limitation of the STFI load-elongation recorder. Although it might be argued that papers stronger than 17 lb. per 15 mm. width might be tested by using narrow test specimens, this practice should not be encouraged because the load-elongation characteristic and the tensile strength of paper are not proportional to the specimen width, as shown in Report No. 29, Part I (*1*). For specimen widths just under 15 mm., the tensile strength per unit width falls off sharply. This is attributed to the existence of zones adjacent to the cut edges which have inferior strength characteristics.

The maximum speed at which the chain motor can raise the chain determines the minimum amount a specimen must elongate under a given load in order that the recorded curve will be reasonably accurate. Curve a of Fig. 3, which has the maximum possible slope, was obtained by starting the chain and pen motors and blocking off the light beam. From this it was determined that a specimen must elongate at least 0.105 mm. for each kilogram of load if the weighing mechanism is to keep up with the applied load. Actually, of course, the specimen should elongate at a greater rate than this, so that the beam can oscillate. The choice of greater spans helps to avoid difficulty associated with this limitation of the equipment.

TESTING OF PAPER ON THE STFI APPARATUS

Although the load limitation of the STFI load-elongation equipment limits the types and grades of paper which may be tested, several papers representing a wide range in type were found which could be tested, and which have been employed for the purposes of (1) obtaining illustrative STFI curves of load versus elongation, and (2) comparing the curves with those obtained for the same papers through the use of the Baldwin-Southwark universal testing machine installed in the Container Section of the Institute. The Baldwin-Southwark equipment has load ranges varying from 0–0.6 to 0–60,000 lb., and ranges in rate of elongation varying from zero to 6 in. per min. Because of limitations of the load-recording system, and because certain papers have a large (load/width)/(strain) ratio, not all of the foregoing rates of elongation are realizable with high accuracy; for example, in the testing of paper, the top rate corresponding to good accuracy is usually 0.3 in. per min. (ten times the elongation rate of the STFI instrument).

Table III. Description of the Papers Tested

Paper	*Basis weight (25 × 40–500), lb.*	*Caliper, 0.001 in.*	*Description*
1	37.4	3.8	75–80% groundwood, 25–20% sulphite
2	27.0	1.2	Supercalendered glassine
3	60.4	3.5	Uncalendered coated paper
4	61.9	3.0	Supercalendered coated paper
5	54.6	4.0	25% cotton bond
6	48.4	4.1	Sulphite tablet paper
7[a]	191	20.8	Blotter stock

[a] The strength of this paper was such that all strips had to be cut to a width of 11.8 mm.; although the results for this paper are, therefore, not properly representative of the load-elongation characteristic, they are satisfactory for a comparison of the instruments.

Seven papers were found which were suitable for the instrumental runs; they are described in Table III.

The STFI recordings for the papers listed in Table III, for a span of 10.0 cm., and for the machine and cross-machine directions, are presented in Figs. 4 to 10. In each case, the curves for the machine and cross-machine directions are designated by the letters a and b, respectively. Each curve is for an individual specimen, and the specimen is not equivalent to the average for the given sample: it is an actual recording (done on blank paper so that details may be seen more clearly), presented in the interest of demonstrating the quality of the recorded curves. Points calculated from the averages of the STFI curves (there were five recordings for each sample and for each principal direction) are designated by circles. Points calculated from the averages of the Baldwin-Southwark curves are designated by crosses. The Baldwin-Southwark machine was operated at a rate of elongation (0.0295 in. per min.) equivalent to that of the STFI equipment (0.748 mm. per min.), and the span was set at 10.0 cm. In each case, the terminal points give the average tensile strength and the average stretch. On comparing the STFI and Baldwin-Southwark points, it will be seen that the agreement is quite good; the average difference between the instrumental results appears to be well within the limits of sample variation.

All the curves obtained with the particular STFI recorder used in the present study exhibit a fine-scale waviness which is definitely ascribable to a slight off-center condition of the pen screw. This fine wave (not of objectionable magnitude) is superposed on a long wave which is present in all recordings, but is most noticeable in certain forms of the load-elongation characteristic (e.g., curves b of Figs. 7 and 9). This long-wave imperfection has the same periodicity as that of the rotation of the elongation drive screw, and undoubtedly results from an imperfection in that drive.

There is a third class of irregularities comprised of a heterogeneous group of fluctuations originating in hunting and accidental effects; these seem to be most prominent in steeply rising portions of the curves (e.g., curve b of Fig. 10—the smooth, steep rise in curve a results from the fact that the load-weighing system of the STFI recorder could not keep pace).

During the testing of glassine specimens it was observed that the breaks often occurred in the lower jaws (usually regarded as evidence of imperfect clamping and, hence, it is common practice to discard data obtained when breaks do not occur in the span between the two pairs of jaws). Inspection revealed that the hole in the movable jaw of the lower pair of jaws (for engagement of the clamping screw) had been drilled too deeply and, in consequence, when the clamping screw was turned up firmly, a small protuberance was formed in the face of the jaw. Specimens taken from the apparatus after a run showed clear evidence of concentration of the clamping load in a small central zone, and also evidence of stress concentration resulting from the localization of the clamping load. Any tendency of the STFI points in Figs. 4 to 10 to lie at greater elongations than the Baldwin-Southwark points might well be the result of this jaw imperfection. It is obvious that this condition may be simply removed by a change in the design of the jaw assemblies.

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This report is one of a series issued as a part of the Instrumentation Program of the American Paper and Pulp Association. The data in the above study were reported to the Association as Report No. 47, Part I, dated Feb. 20, 1952.

Paper and Packaging Specifications

U. S. GOVERNMENT SPECIFICATIONS

Following is information from Robert B. Hobbs, Acting Chief, Paper Section, National Bureau of Standards, on Federal Specifications of recent issue:

UU-B-36d (Revision), Bags, Paper (Grocers); Price, 5 cents

This revision, promulgated July 29, 1952, supersedes Federal Specification WU-B-36b (June 1, 1950) and Interim Federal Specification UU-B-36c (GSA-FSS), (January 3, 1952). The physical requirements for self-opening (automatic) bags and for square bags are combined in one table, involving minor adjustments in the requirements for square bags. The required tearing resistance is lowered by about 20% of the former values. Basis weights of satchel-bottom bags, popular weight sizes $^1/_8$, $^1/_6$, and $^1/_4$, and heavy weight size $^1/_4$, are increased 10 lb., with corresponding increases in bursting strength and tearing resistance. The former size $^1/_4$ popular weight bag is retained as a lighter weight bag. Dimensions of self-opening and square bags are given to the nearest $^1/_8$ in. instead of $^1/_{16}$ in. as before, with other small adjustments. Military sampling and packing requirements have been revised.

UU-B-613a (Revision), Board, Tag, Manila; Price, 5 cents

Promulgated July 29, 1952, this supersedes Interim Federa Specification UU-B-613 (GSA-FSS). One type and grade is defined, not less than 50% chemical fibers, 24 by 36 in. in size, and manila color unless otherwise specified. Weight is 125 ± 6.25 lb., 24 × 36—500. Bursting strength is 50 points. Packages of 500 sheets are required. Detailed military packing requirements are given.

UU-C-86c (Revision), Cards, Guide, File, Calendered, File-Size; Price, 5 cents

This specification was issued July 31, 1952, and supersedes UU-C-86a and Interim Federal Specification UU-C-86b (GSA-FSS). Horizontal dimension of the larger size is reduced from $14^7/_8$ to $14^3/_4$ in. Tolerances of $^1/_{64}$ in. in short dimensions and $^1/_{32}$ in. in long dimensions are added. Metal eyelets not less than $^3/_8$ in. inside diameter are specified when lower projections are used. Color is changed from "natural white" to "manila," and a tolerance of ±5% on basis weight is added. A sample is required to consist of not less than 20 cards. Military packaging requirements are revised.

UU-B-611a (Revision), Board, Tag, Jute; Price, 5 cents

This specification, issued July 29, 1952, takes the place of Interim Federal Specification UU-B-611 (GSA-FSS). One type and grade is described, not less than 50% hemp or jute, or both, and free from groundwood. Size is $22^1/_2$ by $28^1/_2$ in., with color to match standard sample from procuring agency. Basis weight is 100 ± 5 lb., tearing strength (sum of machine and cross directions) is 635 grams and pH is 5.0. Marking and packaging requirements are given.

UU-C-93b (Revision), Cards, Guide, File (Pressboard, Card-Size); Price, 5 cents

This was promulgated July 30, 1952, and supersedes Federal Specification UU-C-93 and Interim Federal Specification UU-C-93a (GSA-FSS). Tolerances of $^1/_{64}$ in. in the short dimension and $^1/_{32}$ in. in the long dimension and in the height of the tab are added. Covering of printed tabs, when specified, is changed from celluloid to cellulose acetate sheeting or lacquer. Tab cuts of full or wide center position, or $^1/_3$ or $^1/_5$ cut are specified. The colors buff, blue, and salmon are listed. Further details of the fading test are given, but there are no changes in thickness, basis weight, burst, or folding endurance. Marking and packaging requirements are revised.

UU-S-171b (Revision), Seals, Notarial; Price, 5 cents

This supersedes Federal Specification UU-S-171 and Interim Federal Specification UU-S-171a (GSA-FSS). There are no changes in fundamental requirements. The adhesion test and blocking test are described in better detail, and marking and packaging requirements are revised.

(Copies of Federal specifications may be obtained on application accompanied by postal note, money order, coupon, or cash to the Superintendent of Documents, Government Printing Office, Washington 25, D. C.)

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Seventh Engineering Conference, Morrison Hotel, Chicago, Ill., October 13–16, 1952.

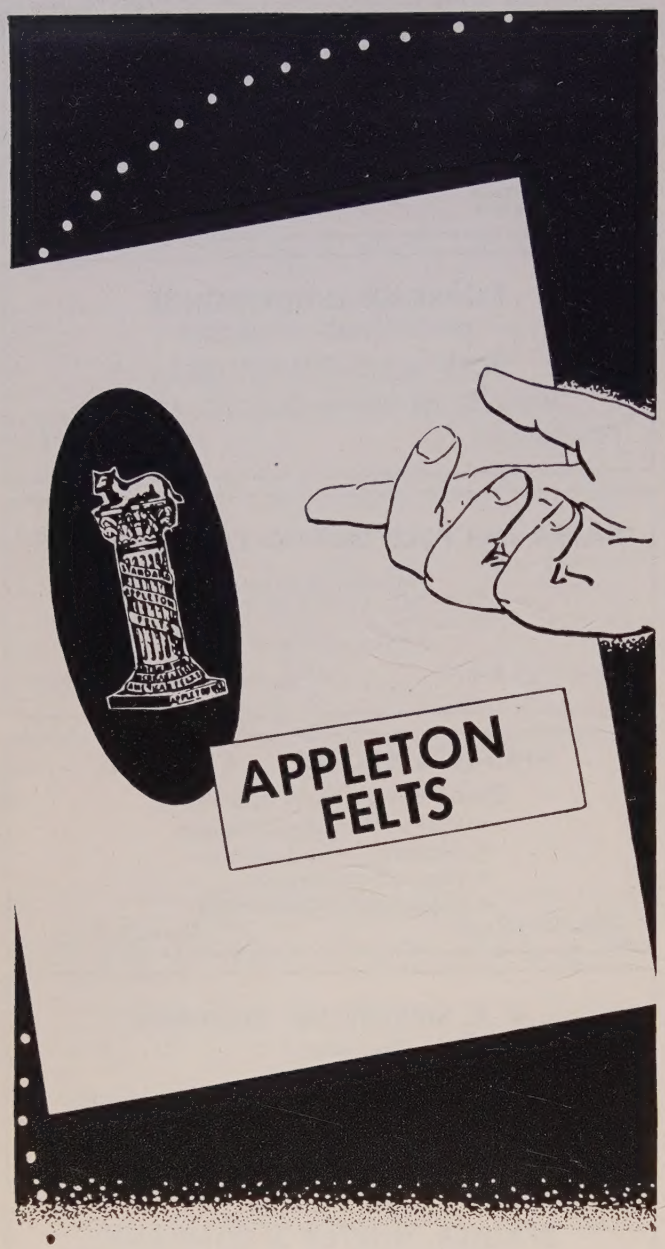
Fibrous Agricultural Residues Conference, Northern Regional Research Laboratory, Peoria, Ill., October 27–28, 1952 (Rooms at Pere Marquette Hotel).

Plastics Conference, College of Forestry, State University of New York, Syracuse, N. Y., November 5–6, 1952.

Alkaline Pulping Conference, Battle House, Mobile, Ala., November 12–14, 1952.

Corrugated Containers Conference, Schroeder Hotel, Milwaukee, Wis., November 20–21, 1952.

Annual Meeting, Commodore Hotel, New York, N. Y., February 16–19, 1953.



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